OCTOBER 1956

SAE Journal

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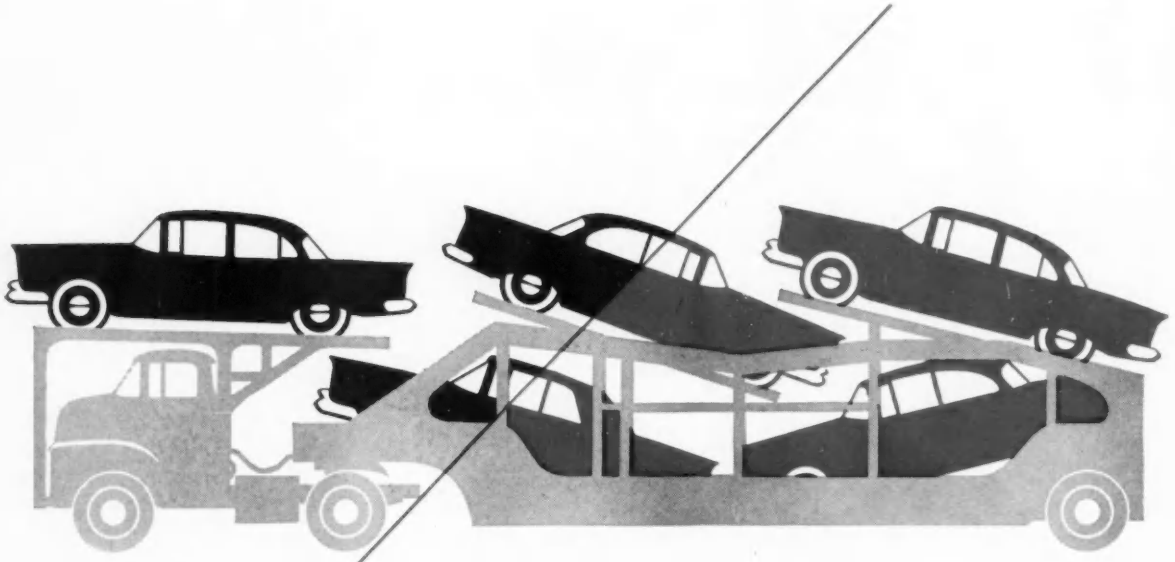
See page 81

Published by The Society of Automotive Engineers



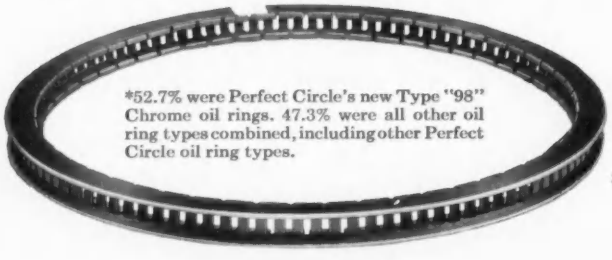
More than half* of the

11,985,000

passenger cars produced in the U.S. from January 1, 1955 through September 1, 1956 were equipped with

PERFECT CIRCLE

Type "98" Chrome Oil Rings



*52.7% were Perfect Circle's new Type "98" Chrome oil rings. 47.3% were all other oil ring types combined, including other Perfect Circle oil ring types.

U.S. patent numbers 2,635,022 and 2,695,825

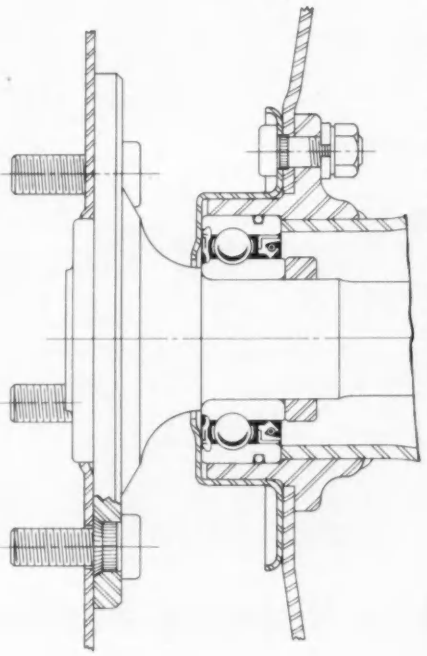
BALL BEARINGS IN REAR WHEELS SIMPLIFY DESIGN AND REDUCE COSTS

New Departure rear wheel bearings eliminate need for locknuts, threads or grooves on axle shafts. One New Departure ball bearing, press-fitted to its seat, locates each axle shaft perfectly . . . resulting in a stronger, more foolproof wheel mounting of simplified design.

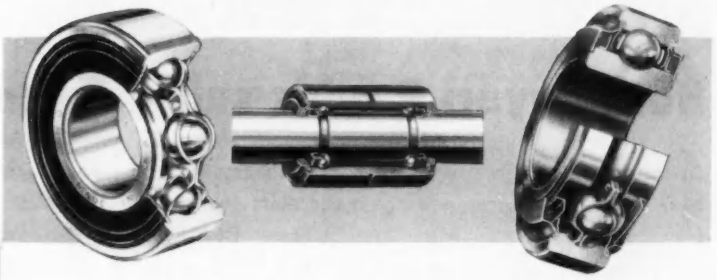
A mounting of lower cost results, too, as leading automotive manufacturers testify. For New Departure ball bearings are sealed and lubricated-for-life. This advantage eliminates the need for grease fittings, felt washers or washer retainers on the wheel side. Unnecessary, too, is costly finishing of the hub for seal contact.

Car owners also reap important benefits from New Departure rear wheel bearings. Press-fitted to seat . . . sealed and lubricated-for-life . . . these bearings never require attention for adjustment or relubrication—they serve for the life of the car. Literally, New Departure rear wheel ball bearings are *built to be forgotten*. New Departure, Division of General Motors, Bristol, Connecticut.

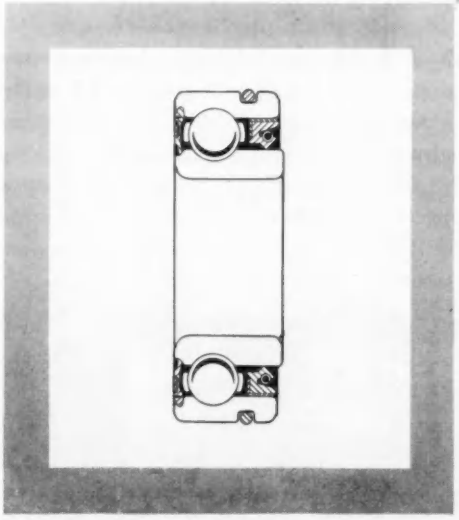
Ball Bearings Make Good Products Better



NEW DEPARTURE SEALED BALL BEARINGS PROVIDE MINIMUM MAINTENANCE—LONGER LIFE



New Departure offers a wide variety of sealed ball bearings for automotive applications of every kind. Full details upon request.



SEE "WIDE WIDE WORLD" SUNDAYS—NBC-TV

NEW DEPARTURE
BALL BEARINGS

GM GENERAL MOTORS

NOTHING ROLLS LIKE A BALL

How Mayari R adds sales appeal to Hackney bodies

In the highly competitive market for delivery truck bodies, the body-maker is ever on the alert for sales features to build into his product. Hackney Brothers Body Company, century-old firm in Wilson, N. C., puts the structural advantages of Mayari R high-strength, low-alloy steel to good use in adding sales appeal to Hackney bodies.

They made the corner posts for this ice cream truck body of Mayari R in order to secure higher strength and higher resistance to "dinging" without increasing body weight. Other framing members of this same body are fabricated from Mayari R to reduce weight without sacrificing strength.

These results are possible because Mayari R sheet has a yield point considerably higher than that of carbon structural steel. In addition, Mayari R has far superior resistance to corrosion, holds paint up to 80 pct longer, and has excellent impact properties. It is readily weldable by all the usual methods.

Throughout the automotive industry, more and more vehicle manufacturers are using Mayari R for framing members, gussets, roof bows, side sheets and other parts in which strength and weight are critical factors. Our Catalog 353 illustrates the wide range of automotive applications for Mayari R. You can get a copy promptly through the Bethlehem district sales office nearest you.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Mayari R...High-Strength, Corrosion-Resisting Steel

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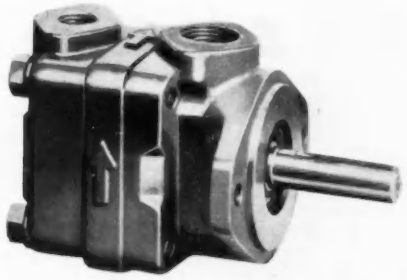
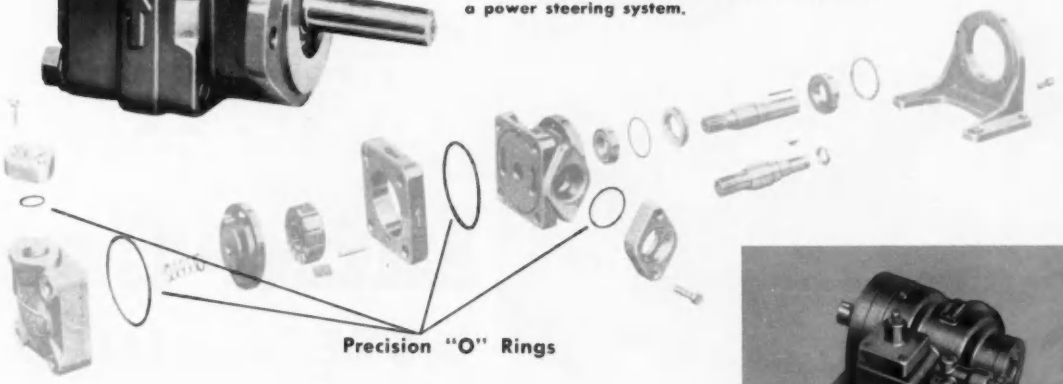
Precision "O" Rings protect the Heart of Hydraulic Power Steering Systems.



Precision "O" Rings provide positive hydraulic oil seal in this 1500 P.S.I. Mobile pump in a temperature range up to 160°F. Quality control in "O" Ring manufacture protects this heart of a power steering system.



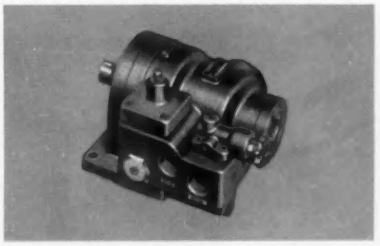
Precision "O" Rings

There can be no compromise on quality and reliability in hydraulic power steering pumps. VICKERS Incorporated, of Detroit, Mich., the world's largest manufacturer of fine hydraulic pumps, use Precision "O" Rings to assure dependable, long life performance under exacting conditions.

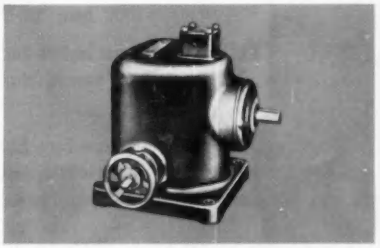
Precision "O" Rings are used in the majority of VICKERS mobile and industrial hydraulic pumps. For VICKERS Incorporated and hundreds of other manufacturers, the use of Precision "O" Rings means economical, efficient, leak-proof operation.

Precision compression molded "O" Rings are rigidly inspected – quality-controlled – meet all military and commercial specifications – the finest made! Precision can furnish the size and compound that fits your product requirements.

Place your sealing problem in the hands of an expert – the Precision engineer. He can assist you in product design. Rely on Precision, the world's largest exclusive producer of "O" Rings.

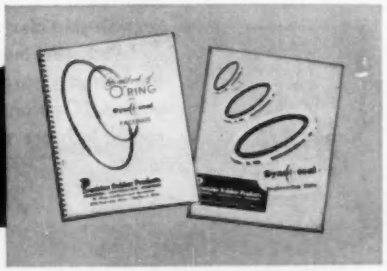


In VICKERS constant delivery vane type pumps, used on Industrial machinery, Precision "O" Rings are used in pump, unloading and pressure relief valve sections to provide effective seals against hydraulic oil leakage.



In VICKERS variable delivery piston type pumps, used on Industrial machinery, Precision "O" Rings give exacting service in sealing against hydraulic oil pressure up to 3000 P.S.I.

Write for your free copies of Precision catalogs on "O" Rings and Dyna-seals



Precision Rubber Products Corporation • "O" Ring and Dyna-seal Specialists

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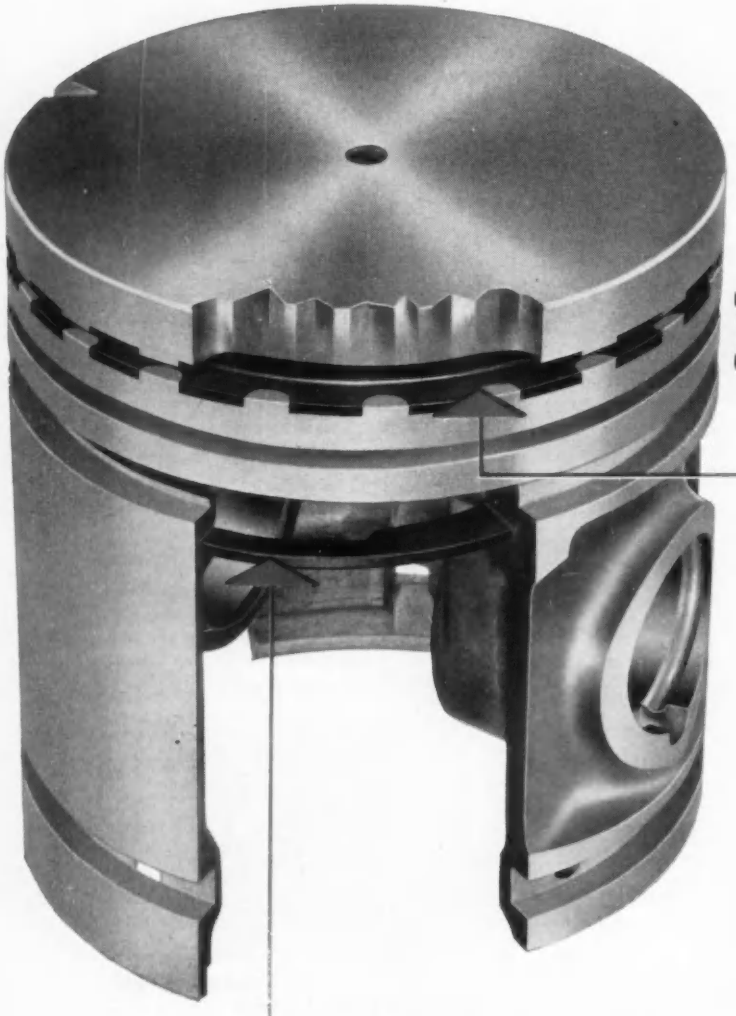
Canadian Plant at: Ste. Thérèse de Blainville, Québec

NOW! STERLING CONFORMATIC* PISTONS



CONFORMATIC STEEL CONTROL MEMBER, anchored at the pin bosses only, controls skirt clearance . . . hot or cold! The metered steel insert allows you to specify the piston clearance *you* want for your engine. (Clearances from zero to ½ thousandth inch are generally recommended.)

are available with LOW COST Intra-Cast* STEEL-LINED GROOVES

***Steel protection—top and bottom*—gives sensationally longer life to rings and grooves.**

This ring is *integrally cast* into the piston . . . positioned so that when the grooves are machined, the top ring groove is *lined with steel* and has islands of aluminum for ring cooling. This Intra-Cast steel-protected groove resists enlargement and materially reduces top ring land wear and rounding. And, it does it at far less cost than other methods.

** Tradename Registered*

STERLING ALUMINUM PRODUCTS INC.

ST. LOUIS, MISSOURI

Diesel-Powered
WHITE 9000

ANOTHER NEW WHITE ...STEERED BY ROSS

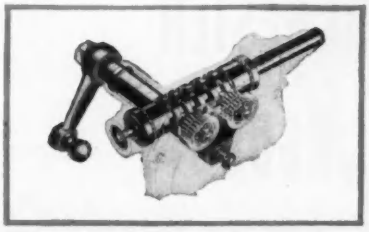
Ross STEERING

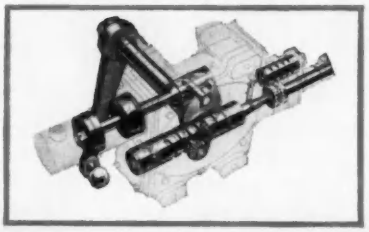
● **New WHITE 9000** with 90-inch dimension from front of bumper to back of cab for maximum "L" dimension. Handles 35 ft. square-nose trailer within 45 ft., or 40 ft. trailer within 50 ft. limit, with three different king pin settings—24″, 30″ and 36″.

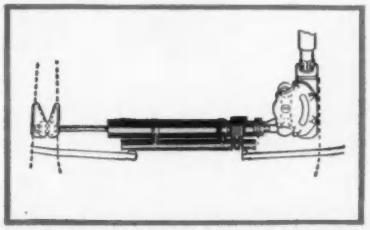
Another outstanding feature that helps make the WHITE 9000 a brilliant new "dimension" in truck-power is — easy, safe, economical *ROSS Steering*.

For 50 years Ross has anticipated and met the *everchanging* needs of the industry for new, finer steering performance, safety and economy. Ross invites discussion of *any* steering problem—manual or power.

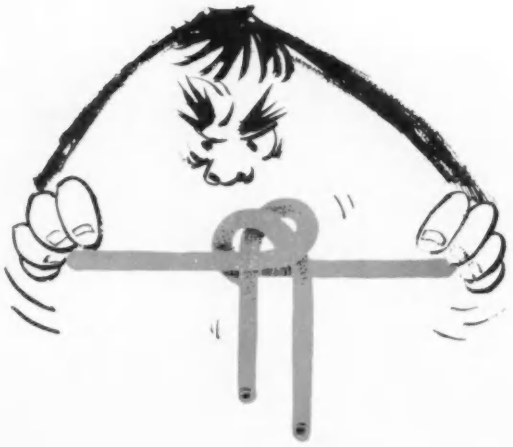
ROSS GEAR AND TOOL COMPANY, INC. • LAFAYETTE, INDIANA







CAM & LEVER MANUAL . . . HYDRAPOWER INTEGRAL . . . HYDRAPOWER LINKAGE



PUZZLED BY TUBING PROBLEMS?

GM STEEL TUBING IS RIGHT AT HOME ON THIS RUGGED RIG!

Packed with power for maximum payloads! GMC features dependable 2-cycle diesel engines . . . with dependable fuel manifolds of GM Steel Tubing.

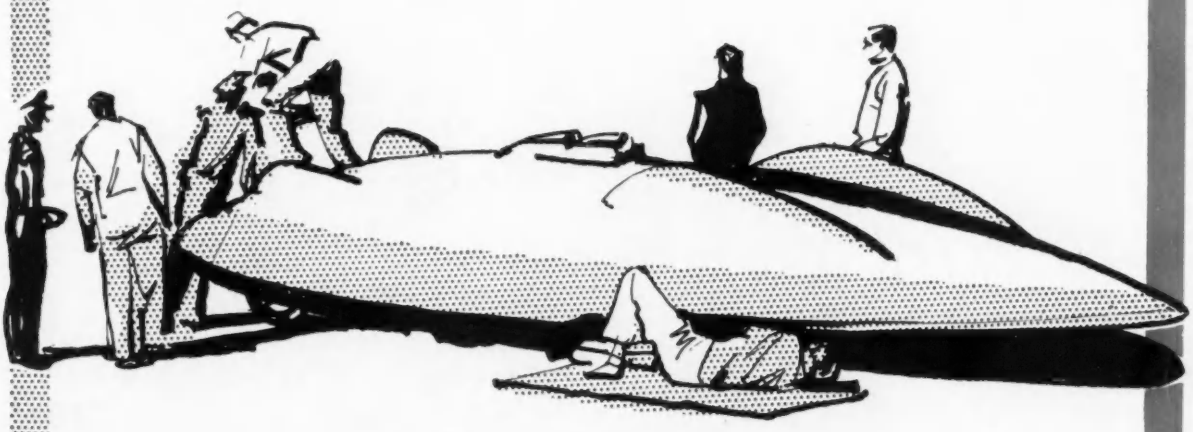
It takes rugged construction to meet extreme road and load conditions. That's why GM Steel Tubing's "at home" *here* and on other heavy-duty equipment from tugboats to tractors. Designed to take it and to take any shape, GM Steel Tubing will help assure *your* product's dependability, too. Rochester Products Sales Engineers are ready to show you how.

GM STEEL TUBING BY ROCHESTER PRODUCTS

ROCHESTER PRODUCTS DIVISION OF GENERAL MOTORS CORPORATION ROCHESTER N.Y.

World Records

World Land Speed Record drivers Segrave, Campbell, Eyston and Cobb all relied on E.N.V. gears. Their records of success are tributes to the quality of E.N.V. products.



and World Markets

E.N.V. are manufacturers of all classes of bevel and hypoid gearing, helical and spur gearing, final drives and transmission units. They invite enquiries from companies in the United States of America wishing to develop the manufacture and sale of engineering products in Britain, Europe and the British Commonwealth.

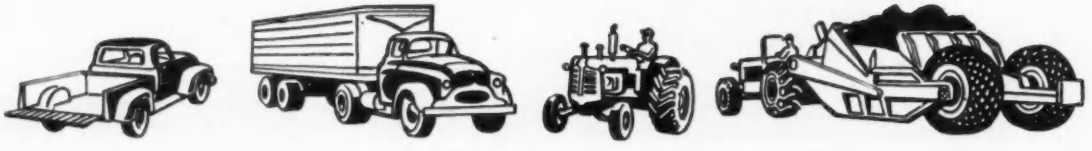
Co-operation with E.N.V. brings the manufacturing resources of modern equipment comprised in two factories covering over a quarter of a million square feet, a capable and experienced labor force and the technical and general experience to gain access to new and expanding markets in many lands.

ENV

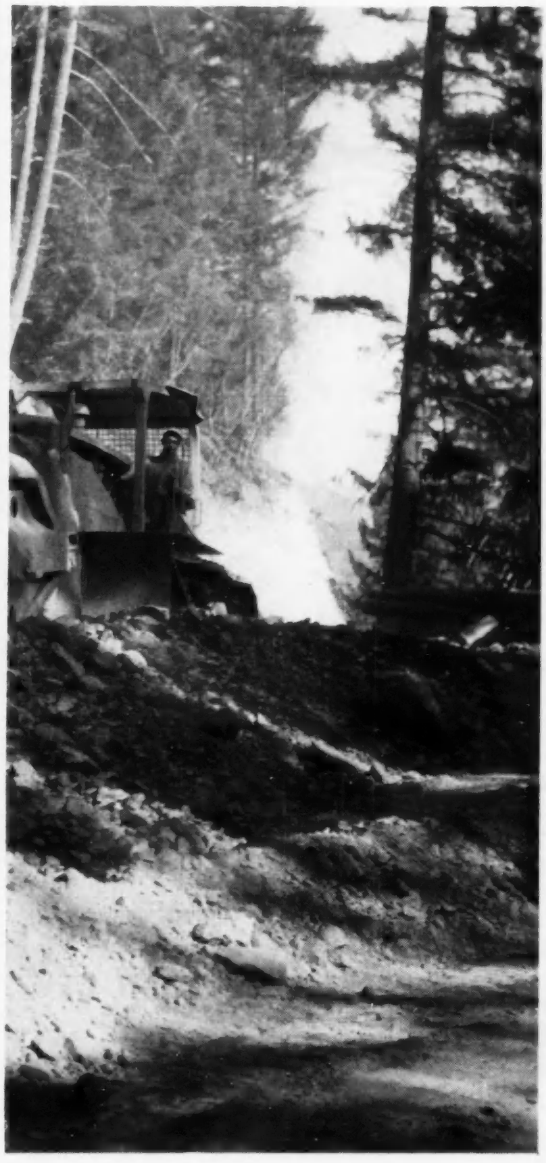
E.N.V. ENGINEERING COMPANY LTD. HYTHE ROAD, WILLESDEN, LONDON, N.W.10, ENGLAND

The rim that on the world's

New Tru-Seal Rims —for sizes 12:00 and up, including all earth-mover and grader sizes. This rim is similar to multiple-piece rims now in use — PLUS airtight Tru-Seal rubber ring which compresses into locking groove when tire is mounted.



put tubeless tires toughest jobs



WE DON'T have to tell you what an advantage tubeless tires are in grinding, grueling off-the-road operations. You're looking at the rim that has made this possible: Goodyear's remarkable new Tru-Seal Rim.

This notable rim development embodies the famous Tru-Seal principle (shown in diagram)—the only workable and economical method ever devised to seal a multiple-piece rim. This permits the practical use of tubeless tires on all vehicles using size 12:00 or larger tires.

Yet Tru-Seal is just one of the many advances stemming from Goodyear's long years of leadership in rim construction. With Goodyear Rims you get:

Unusual Strength: Thanks to an exclusive double-welding process, and added support at points of greatest stress, present day Goodyear Rims are far stronger than previous rims.

Ease of Tire Mounting: No tube and flap troubles.

Special Tools: Goodyear alone provides both hydraulic and hand tools especially made for off-the-road equipment.

Bond-a-Coat Finish – This protective coating affords long-lasting resistance to rust and corrosion.

What's *your* rim problem?

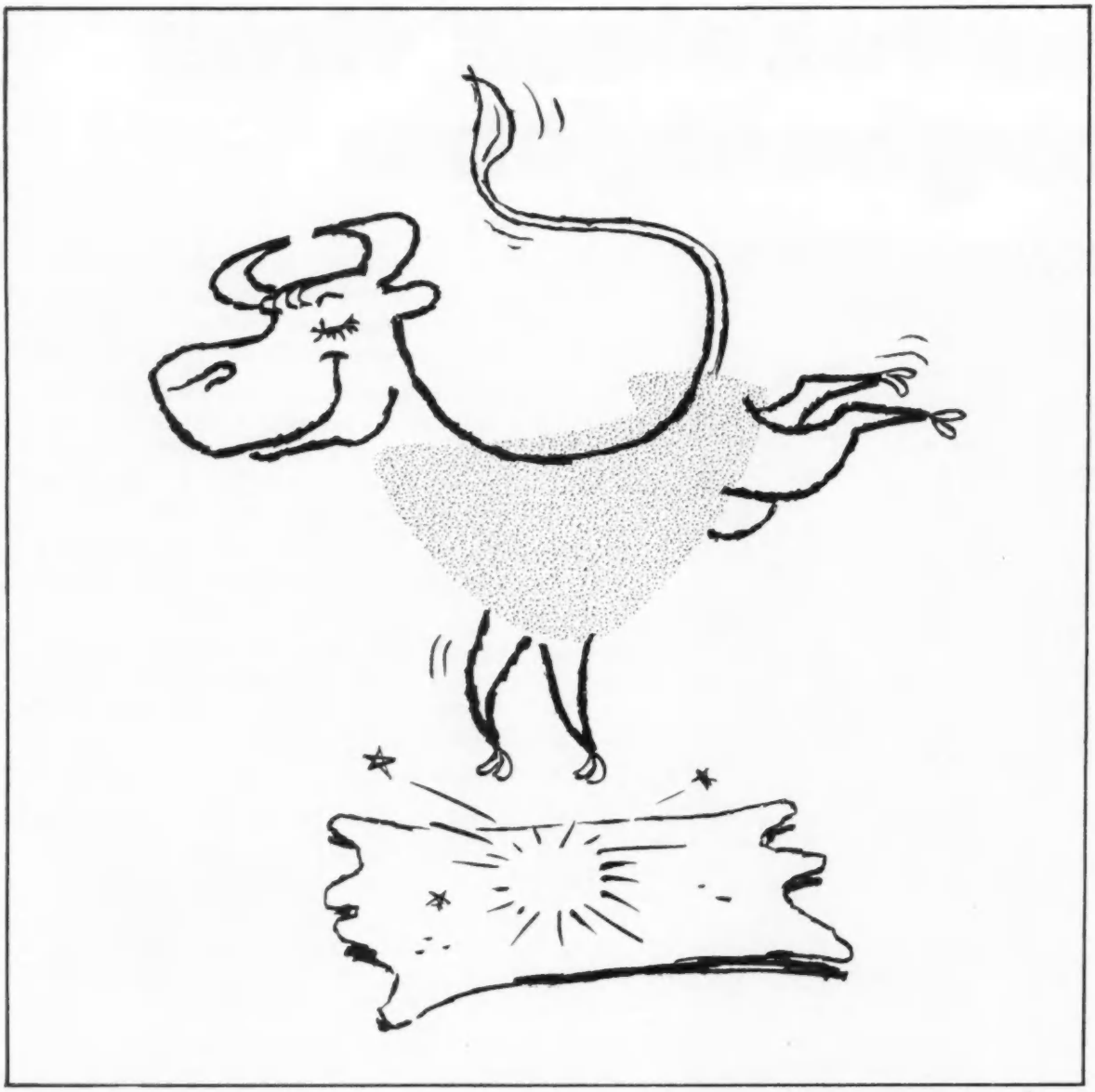
Result of these Goodyear-pioneered rim improvements is the virtual elimination of down time due to rim failure. Why not profit by these advantages when solving your rim problems? The G.R.E. (Goodyear Rim Engineer) will help you select the type and size of rim best suited to your needs. Write him at Goodyear, Metal Products Division, Akron 16, Ohio, or contact your local Goodyear Rim Distributor.

Buy and Specify

GOODYEAR

Tru-Seal–T.M. The Goodyear Tire & Rubber Company, Akron, Ohio

MORE TONS ARE CARRIED ON GOODYEAR RIMS THAN ON ANY OTHER KIND



For practicality... genuine Leather

Genuine leather is the best upholstery material you can recommend for people who want outstanding performance. It is scuff-resistant, strong, nearly impossible to tear, and proof against all kinds of food stains. If the car you sell is going to get real family-style use, your customer *needs* genuine leather upholstery.

Only genuine leather wears as well as it looks

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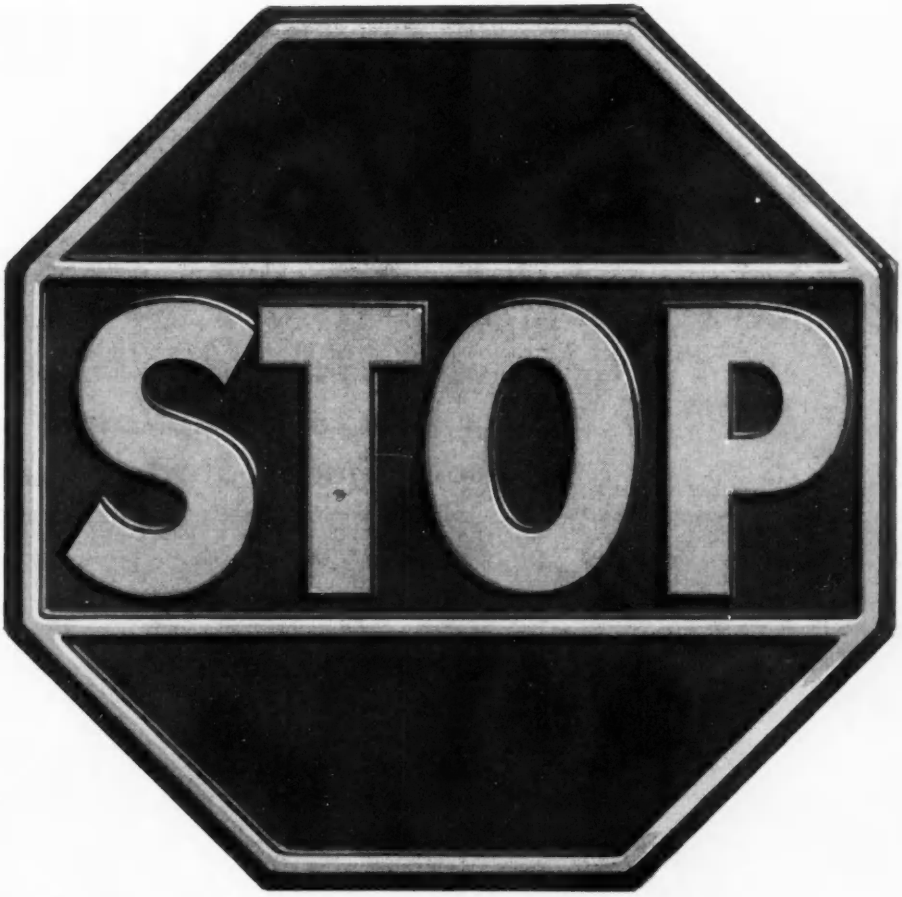

The drafting stage—not later—is the time to design-in oil seals!

Oil seals are precision products. They are designed to operate under a specific set of conditions. Change just one of those conditions—lubricant, shaft speed, temperature, even bearing position—and a different seal will almost always be needed.

Why chance costly retooling or remanufacture? Specify the correct seal on the drawing-board. And when you do, get all the information there is on new seals, new lip compounds, and mechanical designs. Get it from your National Oil Seal Engineer. His counsel is complete, up-to-the-minute, and accurate. You couldn't buy better oil seal information, yet his help is yours for the asking.

Why "do it yourself?" Call the nearest National Oil Seal Engineer now.

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- **Cuts Production Costs**
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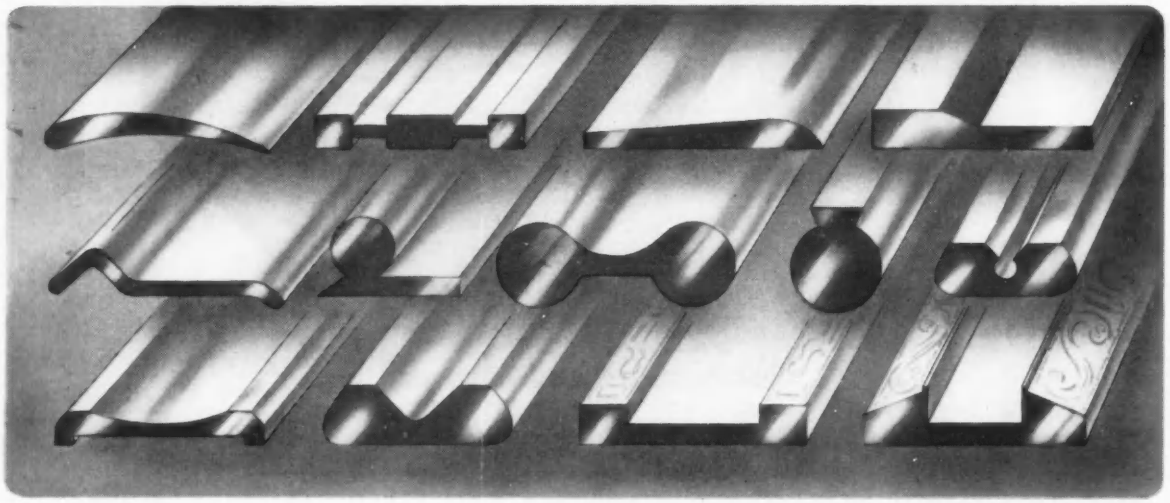

You can profit by using General Plate Rolled Form Stock.

Metals & Controls Corporation

GENERAL PLATE DIVISION

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General Plate craftsmanship can mean substantial production and assembly savings to you, and at the same time minimize your rolled stock inventory problems. Here are some of the advantages available to you in General Plate rolled form stock:

1. Close tolerances in dimensions, contour, and composition.
2. Wide diversification of available metals and shapes.
3. Excellent surface finishes.
4. Heat treating facilities available.
5. Size range from .025″ to 3½″ wide.

These advantages, plus expert toolmaking — skilled production people — efficient delivery service — all resulting from years of experience in producing rolled form material — make General Plate a dependable source of supply for your formed stock needs.

We'd like to figure on your rolled form stock requirements — if you'll send information to help us quote, we'll be glad to estimate tool and material costs without obligation. The information we need is: (1) cross-sectional sketch or drawing and dimensional tolerances, (2) length of strip and tolerances, (3) material specifications, (4) permissible edge curvature and flatness, (5) surface finish required, (6) hardness, and (7) quantities involved.

For the Sake of Argument

To Be Understood is Work . . .

By Norman G. Shidle

We all like to be understood. Firm friendships are based heavily on mutual understanding. Fruitful business relationships rest on the same foundation. Personal satisfactions with accomplishment are closely related to having others understand what we have done.

Yet most of us expect the other fellow to do most of the understanding. We shun the hard work necessary to implement our desires. Ever-present inertia too often wins out over the wish for an intangible future good.

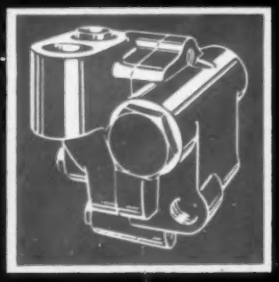
Every one of us is prone to blame his listeners or his readers for failure to take in what he thinks he put out. But, when listening or reading himself, he criticizes sharply the fuzziness of expression which is the earmark of fuzzy thinking.

The higher our rank in a business organization, the greater is our need for being understood. If a research section head asks a few lab assistants for "frequent" reports, little is lost if he begins to get daily reports instead of the monthly ones he had in mind.

But if the president gets similar misunderstanding of a similar request to his operating vice-presidents, it's a different story. Thousands of dollars can go down the drain through the scores of people energized to collect and submit data required for even one unwanted report.

"Everything worth while in life is worth working for." . . . That includes the thinking-before-trying-to-communicate necessary to make ourselves clear to our fellow-men. It's a desirable thing to do in our personal life. It's almost essential to harmony and progress in our business lives.

EATON PUMPS



The Pump Source of the Automotive Industry

EATON MANUFACTURING COMPANY

Pump Division

9771 French Road • Detroit 13, Michigan

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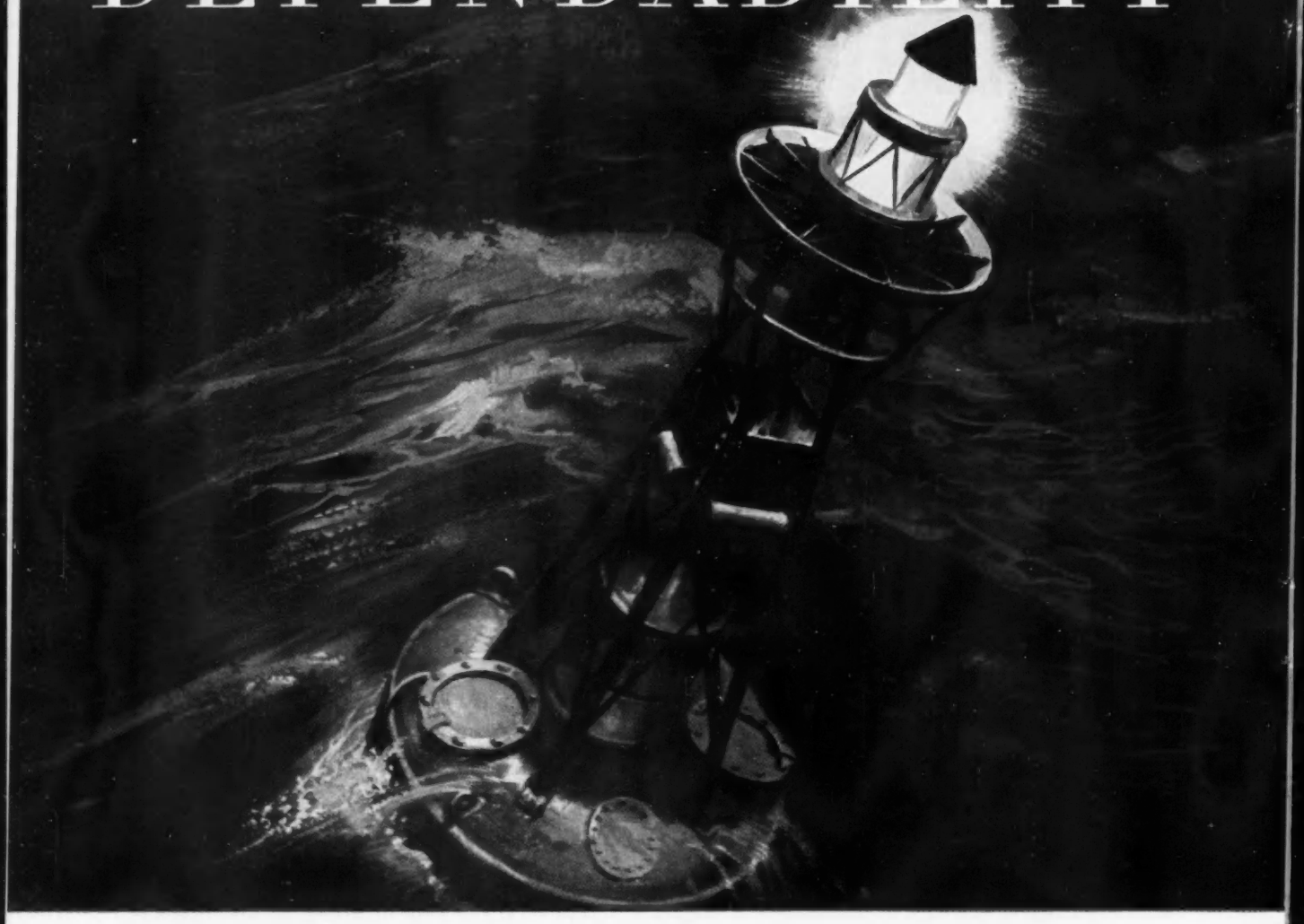
DEPENDABILITY



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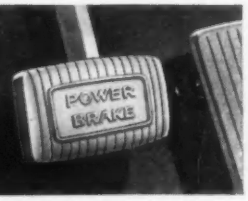

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William M. Holaday
Deputy Assistant Secretary of Defense for Research and Development

Excerpts from paper "Fuel for Thought" presented at SAE National West Coast Meeting, San Francisco, Aug. 6, 1956.

FUEL for THOUGHT

Making the most of our petroleum resources is a goal toward which petroleum technologists and equipment engineers must continue to work jointly—the petroleum technologists improving treating processes and the equipment engineers improving the digestive abilities of their engines.

IN improving the quality or yield of any of the large-volume petroleum products, there is always some effect on one or more of the remaining products. Occasionally this is a beneficial effect. More often it tends to be an adverse one.

For decades—apart from the World War II period—the chief aims of the petroleum industry have been increased yield and improved quality of motor gasoline. For the foreseeable future, the aims are not likely to change.

Our processing techniques fulfill these primary needs, but frequently they depress the quality of other products—particularly that of diesel fuel, home heating oils, and residual fuel oils. Generally the effect of making more and better gasoline is to produce heavier, less volatile, and less stable distillate and residual fuels, which additionally contain less hydrogen and more carbon.

The efficient use of these materials in transportation, industrial, and residential equipment is a tribute to the combined efforts of the petroleum people in effecting some improvements by means of various treating processes and to the equipment engineers in improving the digestive systems of their equipment.

To make sure that the petroleum industry follows the proper course in the future, the equipment design and operating engineers must give serious thought to just what they need in the way of fuel type and quality characteristics. And they must pass their best thinking on to the petroleum people.

One example within the last decade to illustrate this point is the change in the fuel quality requirements of diesel locomotives. More exactly, since the engine requirement hasn't changed, this was a change in the thinking of the design and operating engineer as to what the engine needed for satisfactory operation. As a result of the initial demands for high cetane number locomotive fuel, processing equipment was installed in several refineries to raise cetane number only to find a few years later that the ignition quality of the original fuels was more than satisfactory. The uneconomic result of this impaired foresight to both the petroleum and consuming industries is obvious.

For motor gasoline the present petroleum technology indicates a ceiling—or more probably—a plateau—at an octane number level of 108 (AGAC—that is by the method devised by the Aviation Gasoline Advisory Committee of the wartime Office of the Petroleum Coordinator). Whether or not this quality is needed, can be produced economic-

ally, and can be used efficiently is not yet known. But, strictly from the process point of view, this is as high as can now be predicted—and this includes some optimistic thinking with regard to processes still in the hands of the research people.

Behind this prediction is the fact that the petroleum industry is installing catalytic reforming units at an amazing rate.

(Catalytic reforming consists of taking straight run or cracked gasoline and passing it over a suitable catalyst which promotes dehydrogenation, isomerization, hydrocracking, and desulfurization reactions to give a high octane number gasoline containing 50 to 60% aromatics in the debutanized product. The more paraffinic stocks give reformates having considerably improved anti-knock quality at a given yield. The more naphthenic stocks give even higher octane number products.)

In January of 1952 cat reforming capacity amounted to less than 100,000 bpsd (barrels per stream day) with a large part of this consisting of facilities built during World War II for the production of aromatics. In the next two years, an additional 200,000 bbl of daily capacity was installed, followed, in the next two years, by the installation of more than 675,000 bpsd capacity. The continued trend for catalytic reforming facilities is difficult to predict at this time. Nevertheless, there are indications that 1960 capacity will exceed 1,500,000 bpsd.

Domestic Refining Operations

July 1956

Process	Capacity, bpsd	Function
Atmospheric Distillation	9,000,000	Separation of hydrocarbons by size or type
Vacuum Distillation	2,400,000	
Solvent Extraction	< 30,000	
Thermal Cracking[1]	2,050,000	Reduction in molecular size[2]
Catalytic Cracking	3,800,000	
Hydrocracking	—	
Thermal Polymerization	150,000	Increase in molecular size[2]
Catalytic Polymerization		
Alkylation	265,000	
Isomerization	< 30,000	Change in chemical nature of hydrocarbons
Hydrogenation	470,000	
Thermal Reforming	360,000	
Catalytic Reforming	1,200,000	

[1] Includes coking and vis-breaking
[2] Usually accompanied by some change in chemical structure

Transportation Fuels from Petroleum

(1956 Estimated Demand: 5,000,000 bpd)

Motor Gasoline	72.0%
Aviation Gasoline	4.5%
Aviation Jet Fuel	4.0%
Liquefied Petroleum Gas	0.5%
Diesel Fuels	9.5%
Residual Fuels	9.5%
Total	100.0%

How Catalytic Reforming of Mid-Continent Naphthenic Stocks Improves Octane Quality

A. Charging Light Naptha

		AGAC Octane No. of Reformate	
	Charge	85% Yield	75% Yield
Research Octane No. Clear	47	85	98
Research Octane No. + 3 ml TEL	69½	95	101½

B. Charging Heavy Naptha

		AGAC Octane No. of Reformate	
	Charge	85% Yield	75% Yield
Research Octane No. Clear	40	92½	100
Research Octane No. + 3 ml TEL	62	99	103

Effect of Cat Cracking on Motor Gasoline

To the builders of gasoline powered vehicles this means, of course, higher anti-knock quality resulting primarily from a major increase in the aromatic content of motor gasoline. As far back as 1932 the engineers of the petroleum and automotive industries gave national recognition to the problems of utilizing sensitive fuels during the Uniontown Road Tests. During these tests the engineers were able to define the problem and to establish some tools and terminology with which to study the problem. Aromatics fall into the category of sensitive fuel components, and we are all acquainted with the potential of such fuels if ways and means are found to reduce the severity of engine operating conditions. Conversely, if engine operating conditions are severe, the performance characteristics of aromatics are poor—as evidenced by the 87 octane number rating assigned to benzene by the F-3 Aviation Method.

Because of the knowledge developed on aromatic fuels during the war and the extensive work now being conducted both by individual firms and through the Coordinating Research Council supported by the American Petroleum Institute and the SAE, the most effective utilization of the high anti-knock potential of these aromatic fuels should result.

The next question then becomes: What effect will this major processing development have on the other transportation fuels?

The principal new factor introduced by cat reforming is the widespread availability of hydrogen in large quantity at relatively low cost. This factor has already started another trend—the large scale installation of hydrogenation facilities.

Prior to 1953 there were no commercial hydrogenation plants of major significance. At the present time, hydrogenation capacity is approaching the 500,000 bpd mark and is projected to reach 1,500,000 bpd within the next four years. Close to two-thirds of this capacity will probably be utilized to pre-treat the charge fed to catalytic reforming units. Another 100,000 bpd may be earmarked for treating such materials as wax and lube oil stocks. This will still leave a substantial capacity available for processing transportation fuels and domestic heating oils.

The availability of hydrogen also opens the door to another processing technique—hydrocracking. In this process (still in the research and develop-

ment stage) catalytic cracking is accomplished under hydrogen pressure. This results in the breaking down of large molecules into smaller ones and the simultaneous hydrogenation of these molecules to saturated compounds—alkanes, isoalkanes, and naphthenes. Desulfurization and removal of trace quantities of nitrogen compounds accompany these reactions.

The resultant product constitutes excellent charge stock for catalytic reforming and cracking operations and, upon distillation into suitable fractions, provides very stable, high quality diesel and gas turbine fuel. The extent to which this process is utilized will depend largely on the progress yet to be made in the laboratory although, for specialized operations such as jet fuel production, the highly desirable product characteristics may overshadow the economic considerations which apply to the more conventional transportation fuels.

Effects on Other Fuels

The use of liquefied petroleum gas as a fuel for trucks and busses should not be affected by the application of catalytic reforming or hydrogenation processes. However, some effect on the total availability of butane may result from the greater use of alkylate in motor fuel, which in turn depends in large part on the extraction of isobutane and n-butane from the output of natural gasoline plants.

Similarly, aviation gasoline production should not be affected by these new refining developments. Aviation gasoline consumption is believed to be at its peak—about 240,000 bpd. Current alkylation capacity is very close to this same figure and alkylation units are still being installed to provide the avgas production facilities required in the event of an emergency, and for blending in high octane number motor gasolines. Depending on the volume demand, a super grade aviation gasoline could be produced consisting of selected alkylate blended with pure aromatics.

Since the end of World War II, alkylation facilities have been expanded from about 175,000 bpsd to the present level of about 265,000 bpsd. Installation of additional facilities should bring alkylation capacity to 300,000 bpsd by the end of 1957. Although current military avgas contains a high percentage of alkylate, the excess capacity makes a substantial quantity of this high octane number component available for use in motor gasoline.

With the projected decline in aviation gasoline consumption, jet fuel use in aircraft is scheduled to increase at a rate of about 20% per year, reaching a level of over 350,000 bpd in 1960. About 90% of this jet fuel will be used in military operations.

With the development and installation of hydrogenation units (and possibly hydrocracking), superior quality jet fuels may well be adopted in military operations. Better high temperature stability and combustion and handling characteristics can be expected. Additionally, and apart from any effect of these changes in refining practices, the operational requirements of military jet aircraft will dictate the production and use of less volatile fuels.

The present trend in diesel fuel use is towards three fuel types—one a high quality product for trucks, buses, and high speed operations in general; the second a low cost so-called "economy" distillate primarily for railroad use; and the third a residual fuel or residual-distillate blend for dual-fuel operation of locomotives, motorships, and stationary diesel powerplants.

The quality of high speed diesel fuels should be improved in certain respects by the application of hydrogenation. Several refiners are currently planning to hydrogenate the cracked stocks used in their diesel fuels to reduce sulfur content and to improve stability. The improvement in stability results from the elimination of certain trace components containing nitrogen, sulfur, or oxygen and from the drastic reduction or elimination of diolefins.

Hydrogenation improves cetane number very little, only from 1 to 3 numbers, unfortunately.

Certainly greater increases in cetane number can be obtained by more severe hydrogenation, but economic considerations at the present time do not look promising. Larger quantities of hydrogen are required than are available from reforming and the pressures required to carry out the hydrogenation result in an expensive unit to build and operate. Eventually hydrocracking may provide a means towards higher cetane numbers—provided hydrogen from a source such as natural gas can be made available at a reasonable cost.

In any event the reduction in sulfur and improvement in stability are both welcome quality improvements from the utilization engineer's viewpoint.

Hydrogenation can also be applied to the "economy" and residual type diesel fuels. However, this application appears doubtful, or at best, limited. Inherently, hydrogenation is a "high-class" treating operation and even mild hydrogenation would add significantly to the cost of those fuels which are priced low largely because they are untreated products.

These same comments also apply to the residual fuels used for bunkering ships and in the generation of heat and electricity. In a sense, hydrogenation of these products—which are largely competitive with coal—is the economic equivalent of selling hydrogen at the price of coal.

In a similar vein, it must be recognized that hydrogen has potentially profitable uses in the manufacture of petro-chemicals (for example, in ammonia manufacture) as well as in the treatment of petroleum products. With this reservation on record, the following improvements can be summarized as the ones most likely to be carried out as reforming and hydrogenation units are added to our refineries:

First of all, a major portion of the hydrogen will be used in pre-treating the charge stocks going to the cat reforming units. This demand will become more pressing with the probable trend towards reforming higher percentages of cracked gasoline.

Second, those refineries processing high sulfur crudes will use the hydrogen to reduce the sulfur in their diesel and light distillate fuels. This will not completely eliminate sulfur from these products but will go a long way in cutting off some of the peaks we have been faced with in recent years. An interesting sidelight in this connection is that

the availability of an effective desulfurization process makes it possible to calculate a realistic difference in value between crude oils of high and low sulfur content. Hydrogenation to improve stability will be particularly attractive where sulfur reduction is also required to give a satisfactory product. In some instances stability improvement in itself will be sufficient to justify this use of hydrogen.

Another use of hydrogen will be to improve the stability characteristics of jet fuels and, if desired, to provide a completely saturated product. Not only will the ordinary storage stability of these fuels be improved but even more important, it is possible to get major improvements in high temperature stability, thereby extending their use as a cooling medium.

Where To From Here?

The principal question for the immediate future is: "How much should gasoline octane number be increased and how rapidly?" The answer to this question depends upon the answers to two other questions, namely "How much will it cost to make each succeedingly higher increment in octane number?" and "How much will the higher-octane-number-requirement engines improve the efficiency of fuel utilization?"

At the same time these questions are being studied, consideration should be given to the possible effects of the gas turbine piston engine displacing all or part of the gasoline engines in new motor vehicle production. A direct and obvious effect if this should occur in the near future is the need for facilities to handle an additional product in the distribution system between the refinery and the customer. The less obvious effects are those concerning the refining practices required to produce the desired new fuel.

If the free piston engine should need high cetane number for good starting and idling, refinery operations would have to be altered radically to produce the large quantities of fuel required. Conceivably processes to convert gasoline to diesel fuel might ultimately be required.

In contrast, modifications in refinery practice to produce large quantities of a fuel suitable for the combustion gas turbine should be easy.

At this stage it is impossible to predict the future for the motor vehicle gas turbine or free piston engine. Certainly in evaluating their possibilities, their performance must be judged against the potentialities of conventional engines designed to take full advantage of 100+ octane number gasoline.

Whatever the final selection, the interests of the ultimate consumer can best be served by the automotive design and operating people sharing their knowledge of equipment requirements with the petroleum technologists who can, in turn, contribute their knowledge of fuel quality possibilities and the costs involved.

(For complete paper on which this abridgment is based, write Special Publications Department, 485 Lexington Ave., New York 17, N. Y.)

New Seal Materials . . .

. . . look promising for automatic transmissions. Here's some information about four of the most promising.

Based on paper by **R. C. Grasby**, Chicago Rawhide Mfg. Co.

NEW automatic transmission seal materials show promise in overcoming the leakage associated with Buna N. These materials are:

1. Silicone.
2. Poly-acrylate rubber.
3. Butyl acrylate.
4. Teflon.

After about 25,000 miles of hard driving, Buna N packings tend to harden. This loss of resiliency, at times, results in leakage. The following materials show promise of overcoming this disadvantage:

Silicone

Silicone has high heat resistance. It softens under the action of oil, however, and when used as a seal should be limited to a maximum temperature of 250 F. The fact that silicone softens while Buna N hardens is an advantage when a spring loaded seal is used because the spring remains in control of the seal. The shaft can be removed and replaced in the same silicone seal and the seal will still function.

Silicone is a somewhat tender material and careful planning of the production line assembly, important for any oil seal, is of even greater importance for a silicone seal.

Poly-Acrylate Rubber

Poly-acrylate rubber, sometimes called PA-21 rubber, is being used increasingly as a packing member for oil seals and much actual field experience has been compiled with this material. PA-21 has a maximum temperature limit of about 350 F. It hardens at about 0 F, but in considering this property of the material, the function of an oil seal should be borne in mind. Assuming good shaft concentricity, as the shaft starts turning, frictional heat is developed and even in very cold weather the material quickly assumes its normal rubber-like consistency.

PA-21 is being used extensively in jet engine air-

craft seals and in engine crankshaft seals on heavy equipment and trucks.

Butyl Acrylate

Butyl acrylate is a synthetic rubber compound similar to PA-21. It is said to have slightly better low-temperature characteristics than PA-21. Test and production experience on this material indicate that it has very good possibilities as a seal material.

Teflon

Teflon is a plastic material. It has excellent heat resistance and can probably be used at temperatures up to 500 F. It has a low coefficient of friction and, consequently, low frictional heat buildup. Since it is a plastic, however, it would appear to be much more vulnerable to assembly damage than oil seals with rubber-like packing members. In addition, Teflon represents such a radical departure in an oil seal material that more than the usual amount of engineering testing would seem necessary before it is adopted for large production runs.

(Paper "Seals for Passenger-Car Automatic Transmissions" was presented at the SAE Passenger Car, Body, and Materials Meeting, Detroit, March 7, 1956. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members, 60¢ to nonmembers.)

Trained Management . . .

. . . is in short supply. Too few companies are looking ahead to develop leaders for the future. The job is a continuing one, beginning now.

Based on report by **C. G. Kelley,** Glenn L. Martin Co.

MANAGING is a profession deserving of the same special training given for other professions. By definition, management is:

1. Leading by persuasion rather than by command.
2. Planning, organizing, integrating, and measuring.
3. Leading with due understanding and balance; using skills and knowledge to manage an activity with the best pace, flow, timing, and turnover.
4. Securing balanced results through the work of other people, consistent with the current and potential economic and social climate of the enterprise.
5. Obtaining results successfully, economically, profitably, and on time for the best interests of customers, share owners, employees, suppliers, and the public.

The objectives which should be set for management development are:

1. Provide managers with opportunities for self-development and advancement on their present jobs as earned.
2. Improve the skill and confidence of the entire management group.
3. Furnish both the number and quality of managers needed in the future.
4. Encourage systematic habits and procedures to make simpler the discharge of managerial duties.

When we consider management development we find there are four parts to the approach, beginning with the climate created by the manager. He establishes the climate by his attitude and behavior, policies and practices, and his standards.

Self-development planning is personal and direct because every manager is responsible for his own and for providing for opportunities and challenges for those under him.

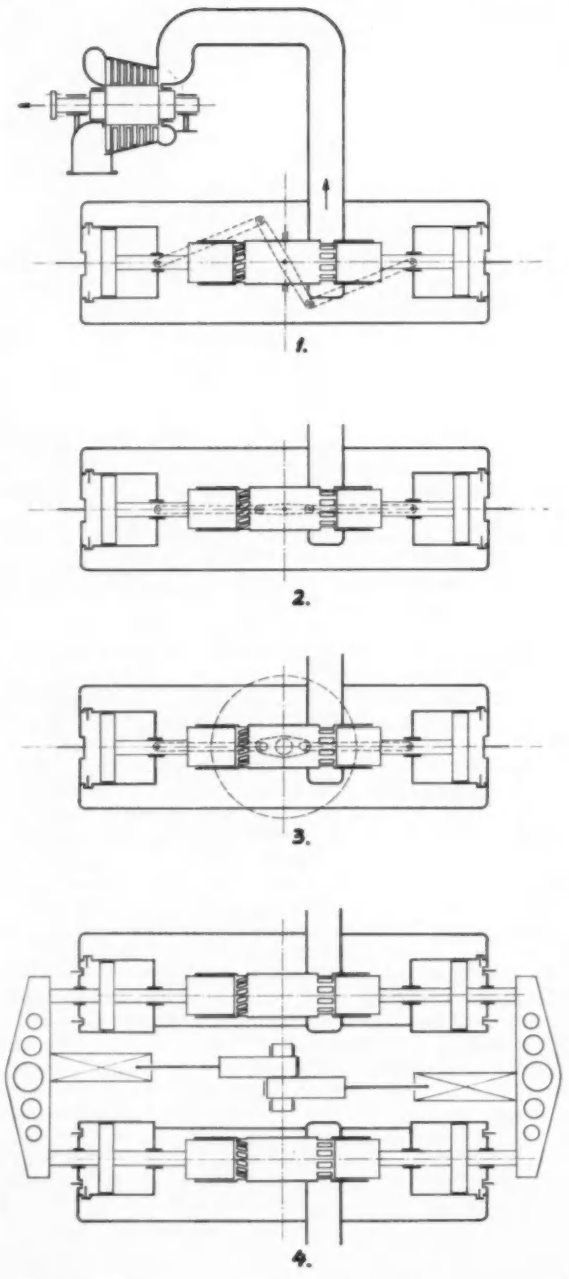
Long range planning looks five years ahead to figure the size and kind of organization needed. Short range planning covers a year and a half for orderly replacements by promotion and placement. Continuity should be planned for in management to insure company continuity.

Manager education, the fourth part of development, begins with education through reading and study. It is also possible to establish business management courses. General Electric has an advanced management course whereby all managers get a 13-week period of education by going to another plant. This has proved very successful. (This article is based on the secretary's report of panel on techniques of modern manufacturing management held at SAE National Aeronautic Meeting and Production Forum, New York, April 9, 1956. Panel leader was G. T. Willey, Glenn L. Martin Co.; secretary was C. G. Kelley, Glenn L. Martin Co. Panel members were: Dugald Black, Bendix Aviation Corp.; Mark Deferranti, General Electric Co.; C. W. Easton, Boeing Airplane Co.; Leonard Giles, Lincoln Electric Co.; N. H. Lou, Republic Aviation Corp.; Nicholas Olijnek, Minneapolis-Honeywell Regulator Co. This report together with 6 other panel reports is available as SP-315 from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: $1.50 to members, $3.00 to nonmembers.)

How "Free" Should a

Prof. Paul H. Schweitzer Suggests—

in discussion of the article "CMR 4-4 HYPREX Free Piston Turbine Engine" by A. F. Underwood which appeared on pages 60-66 of the June issue of SAE Journal. Schweitzer is Head of Diesel Research at The Pennsylvania State University.



MANY of the advantages of the free piston gasifier—with fewer of its disadvantages—can be achieved in a "semi-free piston" engine having a crank mechanism.

The principle of the semi-free piston engine is illustrated by the evolution diagrams shown at the left.

The semi-free piston engine shares with the fully free piston engine the following advantages:

1. **Relatively low gas temperature at gasifier outlet (turbine inlet).**
2. **Simplicity inherent in the small number of moving parts.**
3. **Direct transmission of forces from the power pistons to the compressor pistons without rotating or oscillating components between the two.**
4. **Absence of side thrust on the pistons.**
5. **Perfect balance and absence of vibrations.**
6. **Compactness.**
7. **High thermal efficiency.**

Besides, the semi-free piston engine is free from

CONTINUED ON PAGE 24

1. CONVENTIONAL FREE PISTON POWERPLANT has gasifier, in which the opposed free pistons are joined only by a synchronizing linkage, and a turbine. The cylinder operates on the diesel cycle. As ignition takes place, the pressures force the double-ended pistons apart, uncovering the exhaust outlet to the turbine and later the cylinder intake, and the outer piston ends compress air in the compressor cylinders and charge the power cylinder. With the exhaust outlet open, cylinder pressure drops, and the energy stored in the compressed air in the clearance volume of the compressor cylinders bounces the pistons together again.

2. BY SHORTENING THE CENTER LINK of linkage in conventional arrangement, the stroke can be limited.

3. A FLYWHEEL CAN BE ADDED TO THE LINKAGE and the link made to rotate instead of oscillating.

4. CYLINDERS CAN BE TANDEMIZED AND YOKED rigidly. The crossheads here are connected to cranks. The device can be considered either as a crank mechanism or a synchronizing linkage, depending on the size of the flywheel attached to the shaft.

Free-Piston Gasifier Be?

Arthur F. Underwood Replies—

to the discussion at the left, of the SAE Journal article based on the paper he presented at SAE Summer Meeting at Atlantic City, June 5, 1956. Underwood is Head of the Mechanical Development Department of the Research Staff of General Motors Corp.

THE comments by Dr. Schweitzer on the semi-free piston engine are interesting, but it is difficult to see how the engine which he proposes can be termed a type of free piston engine. The phrase "free piston" signifies that the piston stroke is variable depending upon the operating conditions of the engine. If the piston stroke is crank restricted, then the engine is not a free piston engine, nor a semi-free piston engine.

Dr. Schweitzer's proposal appears to be a different configuration of an ordinary diesel using a piston air compressor, except that it is used as a gasifier for a compound engine.

The absence of a rotating shaft does complicate the drive of pumps, fans, and other accessories. It does not necessarily complicate the injection pump drive.

We are not familiar with Dr. Schweitzer's operating experience with free piston engines, but our experience indicates that several disadvantages which he enumerates are not troublesome.

• When a free piston engine is in satisfactory condition, it is easy to start and continues running without interruption. On the other side of the picture, when a diesel engine is not in good operating condition, it can be difficult to start and to keep running.

• We do not understand why the pistons of the semi-free piston engine are less difficult to cool. Seals are needed and it would appear to require more complication than the usual design.

• If less air were used in order to employ a smaller air cleaner, then the exhaust temperature would be higher. An increase of even as little as 200 F would result in turbine problems which we do not feel are worth the advantage of a somewhat smaller air cleaner.

• The statement is made that the crankshaft and connecting rods do not transmit much force. If the "semi-free piston engine" is designed to store and feed back enough energy to keep the engine running for several cycles when there might be a temporary loss of power, then it would appear that the connecting rods and crankshaft would have to be rather substantial. It should be remembered that the starting forces can be substantial and, if the engine is to be started through the linkage, it is not lightly stressed.

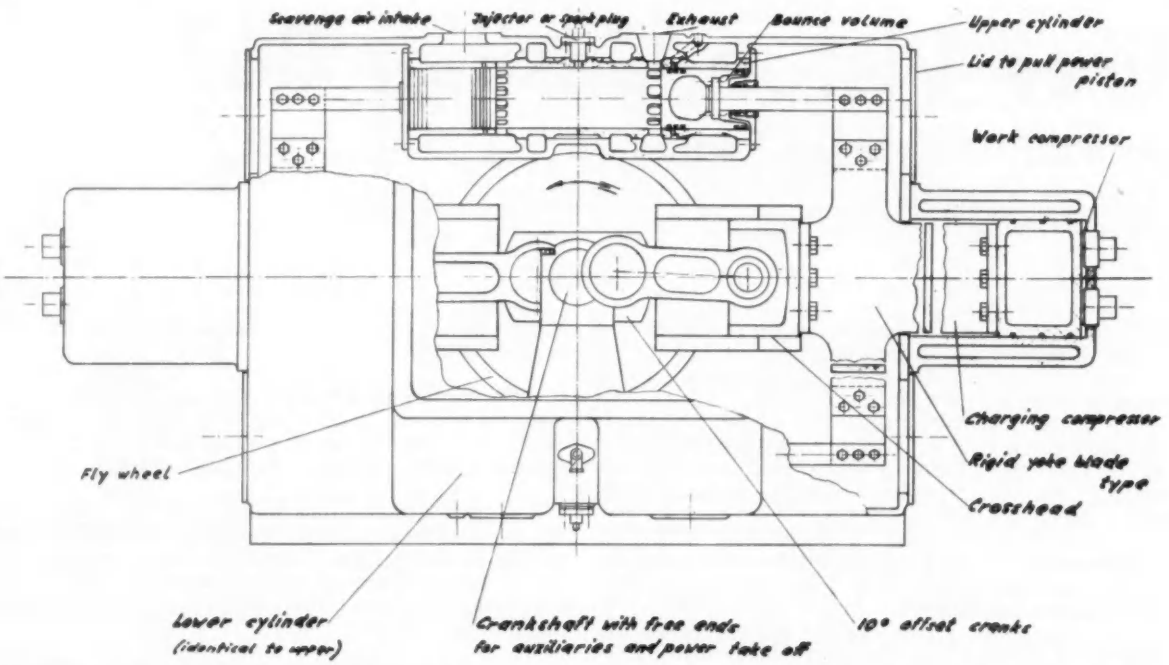
Why Free Piston Gasifiers?

Gasifier-plus-turbine powerplants roughly similar to the one diagrammed at the top are under study for passenger cars, trucks, and buses. General Motors' recently announced GMR 4-4 Hyprex is one such engine. The description of it which appeared in SAE Journal, June 1956, pages 60-66 drew forth the discussion and reply appearing on these pages.

Ford also has revealed construction of experimental gasifiers. (See SAE Journal, July 1956, pages 58-59.)

Reason for current interest in the general free piston type of gasifier is that it results in lower temperatures in the turbine than does the combination of impeller-type compressor plus burner used in turboprops and turbojets for aircraft. Therefore less scarce high-temperature-resistant alloy is required for turbine blading.

The gasifier's exhaust is relatively cooler because the work of compressing the air has been removed in the gasifier. In the aircraft combustion-type turbine powerplants, the turbine must produce the energy to run the compressor, and the gases therefore contain additional energy in the form of heat.



TANDEM SEMI-FREE PISTON COMPRESSOR shown schematically here has yoke, linkage, and flywheel as in bottom diagram on preceding page. The machine can serve as an air compressor. Or if all the air delivery of the compressor cylinders is ducted to the power cylinders to supercharge them, the machine can be used as a gasifier.

CONTINUED FROM PAGE 22

these five disadvantages of the free piston gasifier:

1. Absence of a rotating shaft complicates the drive of the injection pump and—to a lesser extent—drive of the water pump, cooling fan, lube oil pump, and other accessories.
2. If the control fails because of loss of compression or for some other reason, the engine may stall.
3. Starting is awkward because the engine must start at the first stroke. This requires a supply of vacuum and of compressed air, and a thorough venting of the fuel lines before starting. When an engine is not running the fuel lines become partially air bound. In a conventional engine this small amount of air is usually driven out during 10 or 20 revolutions of cranking. If a free piston engine injection system is air bound, the engine simply will not start.
4. The oil cooling of the free pistons is difficult and the pistons are prone to overheating.
5. Unsymmetrical porting—with a desirable exhaust lead on one hand and closure of the inlet ports after closure of the exhaust port on the other hand—is impossible with 180 deg phase angle between the opposed pistons.

The semi-free piston gasifier circumvents all of these disadvantages. Just as important, it can get along on less excess air and therefore a smaller air cleaner. That's because the pistons can be oil cooled through the piston rod.

The Hyprex gasifier is said to run with 400% excess air. Because of this, it would require an air cleaner of five times the capacity of that of a gasoline engine with equal fuel consumption, or say 2½ times that of a gasoline engine with equal horsepower.

A 200 hp gasoline passenger car engine uses less than 10% of its power on the average (15–20 hp at 60 mph). And the air consumption of a carburetor engine is roughly proportional to its horsepower output. So for a large part of its operating time it is not taxing its air cleaner.

The air consumption of a conventional diesel engine is independent of the load. In the Hyprex, with recirculation, it may decrease slightly with the load, but surely not to the same extent as that of a carburetor engine. So the air cleaner capacity required by a Hyprex engine would be many times larger than that of a conventional gasoline engine for the same replacement period.

A turbine engine having a centrifugal or axial-flow compressor may get along without any air cleaner. But a free piston engine needs, if anything, cleaner air than the gasoline engine. Not only are there rubbing surfaces under severe conditions, but also reed valves which lose their seal when dust gets on their seats.

The apparent disadvantage of the semi-free piston machine is the continued use of crankshaft and connecting rods. These parts, however, are lightly stressed because they do not transmit much force. All bearings are away from the engine at a cool and accessible place where they are easy to lubricate.

Current Crash Test Data

Results from improved research are easy to translate into designs

R. H. Fredericks, Ford Motor Co.

Based on secretary's report of Round Table "Industry Report on Automotive Safety Research" at 1956 SAE Summer Meeting in Atlantic City, June 5, 1956.

INCREASINGLY accurate evaluation of test methods has multiplied many times in recent years the design-useful data accumulated from automobile crash researches. Encouraging data have been generated which dispel any resignation to the traffic problem.

Statistics and research studies show that the enclosure of the vehicle itself can provide a potentially high degree of occupant protection. It has been established, for example, that survival during a collision can be at least twice as likely, merely if the occupants remain within the vehicle. Volume statistics have pin-pointed the injury-producing frequency of interior areas of the vehicle. Most of these danger areas can be treated or redesigned to reduce their potential hazard.

It has been found, too, that the structure of the human can withstand considerable force which is properly distributed and controlled . . . and that many car owners are willing to use seat belts when they realize their value in reducing injuries resulting from collisions.

Collision Test Methods Vary

Among the types of test which have been sharpened to more practical usefulness in providing design data are rollovers, barrier crashes, car-to-car crashes, and others.

An automobile snubbing apparatus developed at General Motors to simulate crash impacts is among the newer devices being used to get car-to-car crash results. With this device (Fig. 1), a car is towed to a desired speed, released, and then snubbed on a cable which is attached to a twin hydraulic snubber. Adjustable relief valves preloaded with air pressure control the deceleration rate. The snubbing cable is attached at the rear of the car at the height of the center of gravity. (The snubbing apparatus is designed for decelerations up to 30 g.)

Another new test device is used for measuring floor pan deformation. In one test, its use revealed that, after a 20 g snubber test, the floor pan deformation was only 1 in. (When belts attached to the floor pan are loaded statically, the floor pan will deform up to 6 in. The short duration of the dynamic load is what prevents so great a distortion during actual impacts.)

Tests Improve Lock Design

Much recent crash test work is aimed to provide data for improved door-lock designs, because it is now generally recognized that passengers had best be kept inside the car in a crash. So, much work has been done to reproduce door openings under controlled conditions to get the data needed for door-lock betterment. Car company researchers have found that impacting cars into a fixed object often fails to open the doors—even under reasonably severe conditions.

To get the needed data, Chrysler went to a rollover test in which test cars were towed at 45 mph over a high ramp which catches only the front and rear wheels on one side of the car. As the car reaches the ramp, the tow car is disconnected by breaking the circuit in an electromagnetic coupling. These tests were highly successful in opening car doors.

Chrysler has recorded data from this type of test on a variety of different door-lock designs. Scratch gages determined fore-and-aft door movement which permits door opening. Fig. 2 shows the results of laboratory strength tests for various safety lock designs—and indicates that Design No. 5, selected for 1956 Chrysler Corp. production cars, fulfills the displacement requirements previously revealed from scratch gages tests which determined the amount of longitudinal or fore-and-aft movement of the door with respect to the door-latch pillar. Chrysler engineers say that the large amount of additional extension available at or near full-load-carrying capacity of the latch represents an extremely important feature.

Collision Research Results

Among the vast amount of test results recorded in recent years from automobile collision research,

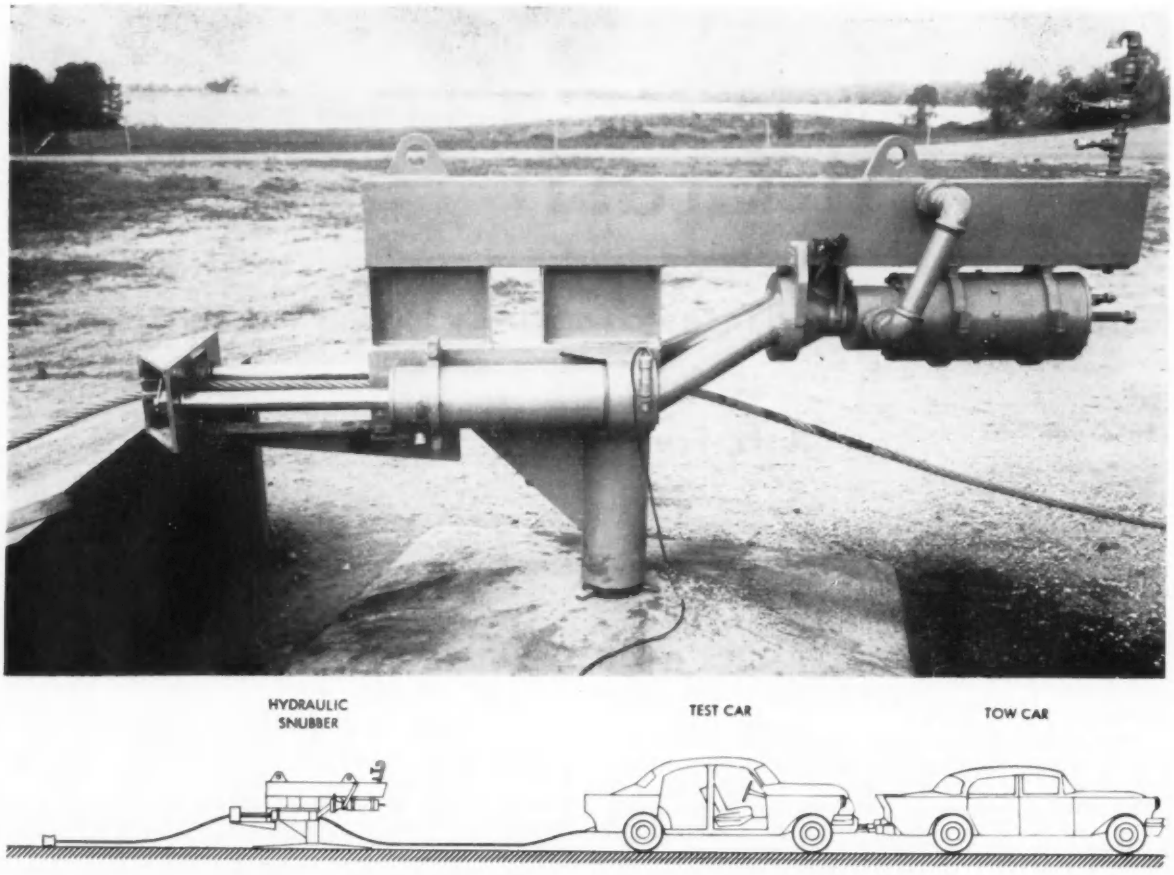
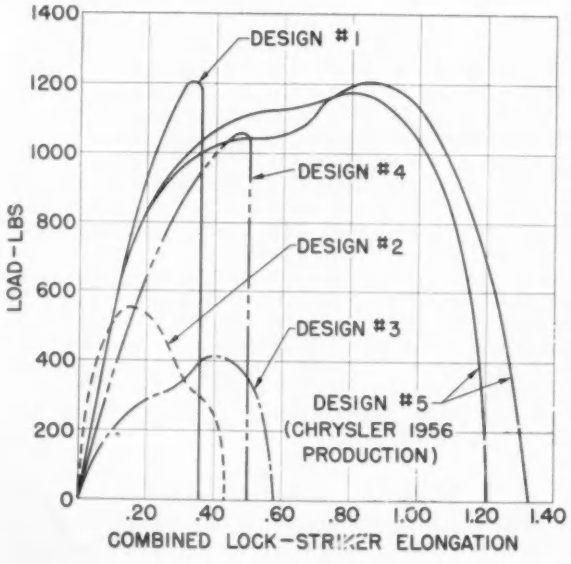


Fig. 1—Hydraulic snubbing apparatus used to simulate automobile crash results. Below is a simplified diagram of this impact simulation equipment used at GM Proving Ground.



some of the more interesting are those produced at Ford Motor Co. Some of the data which Ford has measured and recorded from numerous car-to-car and barrier collision tests with 1955 Ford cars are shown in Figs. 3-7.

In Fig. 3, the passenger compartment decelerations shown are the peak decelerations measured on the floor pan of the passenger compartment just aft of the front seat. The total permanent deformation or overall shortening of the vehicle which results from rigid barrier tests is shown in Fig. 4.

In Fig. 5 the passenger car compartment deceleration curve for barrier crashes (shown also in Fig. 3) is compared to the frame front deceleration measured just aft of the bumper attachment. For the full range of velocities tested, the deceleration level in the passenger compartment always has been less than half that observed at the front of the

Fig. 2—Results of door-lock strength tests for five different door-lock designs. Permissible displacement requirements had been determined previously in car rollover tests by scratch gages which recorded the fore-and-aft movement of the door with respect to the pillar.

Figs. 3-7—Data recorded from numerous car-to-car and barrier collision tests on 1955 Ford cars.

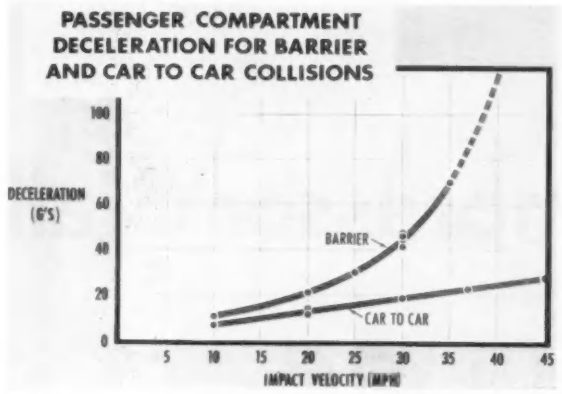


Fig. 3

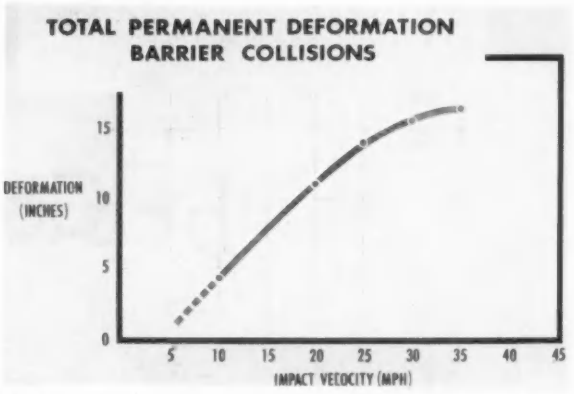


Fig. 4

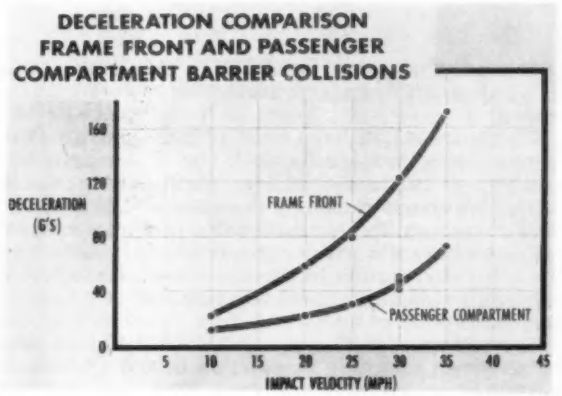


Fig. 5

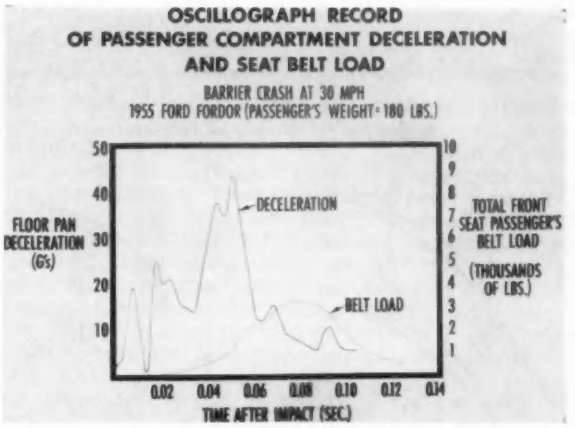

OSCILLOGRAPH RECORD
OF PASSENGER COMPARTMENT DECELERATION
AND SEAT BELT LOAD
BARRIER CRASH AT 30 MPH
1955 FORD FORDOR (PASSENGER'S WEIGHT=180 LBS.)
FLOOR PAN DECELERATION (Gs)
DECELERATION
BELT LOAD
TOTAL FRONT SEAT PASSENGER'S BELT LOAD (THOUSANDS OF LBS.)
TIME AFTER IMPACT (SEC.)

Fig. 6

frame. This indicates that the front structure of present vehicles is a substantially effective energy absorber.

A typical deceleration curve and a seat belt load curve are plotted on the same time scale in Fig. 6. (Data were taken from an oscillograph record.) The seat belt load represents the total loop load measured in the standard Ford Motor Co. seat belt. Note that the peak belt load lags the peak deceleration by approximately 0.03 sec. Also, the peak belt load is less than half of the product of the peak deceleration times the weight of the test dummy.

Fig. 7 shows the measured peak seat belt loads obtained from car-to-car and barrier tests at various speeds. Here again, the belt load is the total or loop load.

In studying these test results, it is important to realize that there are many variations possible in test conditions which cannot be completely controlled when staging full-scale collisions.

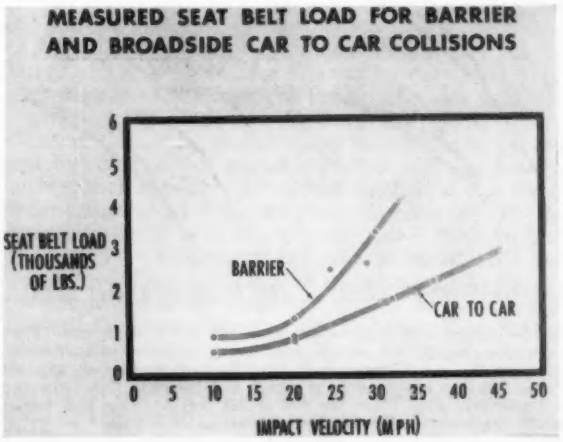

MEASURED SEAT BELT LOAD FOR BARRIER
AND BROADSIDE CAR TO CAR COLLISIONS
SEAT BELT LOAD (THOUSANDS OF LBS.)
BARRIER
CAR TO CAR
IMPACT VELOCITY (MPH)

Fig. 7

Compressor Stall

Fig. 1—Uniform stall of all blades in a blade row (left) is rare. More often, flow instabilities cause a small group of blades to stall before others in the row. The stalled blades dump extra flow on adjacent blades, creating a high angle of attack and therefore flow separation and eventually stall. Then the first blades unstall. Thus stall rotates around the blade row, usually in the direction of rotation.

WE know what compressor stall is. We understand what conditions aggravate it. We have developed some fixes.

What's more, we have built engine controls that more or less satisfactorily allow the engine to accelerate up to its maximum rpm within the pressure ratio-flow area bounded by the steady state and the stall curves on the characteristic compressor map.

But we have not yet developed what appears to be the ultimate solution to compressor surge: a device to sense incipient stall and regulate fuel flow to keep the compressor out of stall.

The effects of stall range from mere loss of performance to complete destruction of the aircraft.

Stall is an extremely serious operating problem with regard to fatigue failures of compressor blades. The local fluctuations due to rotating stall impose periodic force variations on the compressor blades. The frequency of these force fluctuations is frequently of the same order of magnitude as the natural frequency of the blades of one of the compressor stages.

When resonance of these two frequencies occurs, several blade vibrations result. Experiment has shown that rotating stall patterns have sufficiently strong harmonics to incite serious blade vibrations even when the stall frequency is one-half or one-third of the natural frequency of the compressor blades. It is believed that rotating stall is the major source of blade failure due to vibrations.

The Cause of Stall

When the flow through a compressor blade row is reduced, the angle of attack on the blading is increased. If the angle of attack is increased too much, separation will occur on the suction surface of the blading. The occurrence of flow separation is accompanied by a large increase in loss and is referred to as stall of the blading.

At high angle of attack, it might be expected that

Is Well Understood—

But Not Yet Licked

all blades in a blade row would stall uniformly as indicated at the left in Fig. 1. In general, however, uniform stall of all blades of such a cascade is an unstable condition. Normal flow instabilities will cause a small group of blades to stall before the others in the blade row. Separation occurs on the suction surface of the blades in this group. This flow separation results in a severe flow restriction in these blade passages. Furthermore, this group of blades is no longer capable of supporting the pressure rise imposed by adjacent unstalled blades and produces a reverse flow through the stalled blade passages. As a result of these factors, a partly stagnated region is formed ahead of the stalled blade or blades. This region is indicated by the shaded region in the right hand sketch of Fig. 1. The incoming air is deflected around this low flow region. The angle of attack is increased on the blades immediately beyond the stalled blades, and the angle of attack on the blades before the stall region is decreased. Thus, the next blade beyond the stalled region stalls and the last blade before the stall zone unstalls. This process is continuous and the stall zone propagates around the stage. Rotating stall can originate in either stator blade rows or rotor blade rows.

The flow range over which rotating stall usually occurs in the single-stage compressor is indicated in Fig. 2. Reduction in flow results in an increase in angle of attack and in increase in static-pressure ratio which eventually leads to stall of the blade elements. As a result, the static-pressure ratio reaches a peak and then decreases with further reduction in flow. Stage performance becomes unstable at the peak of the curve and rotating stall is initiated at this peak value. Rotating stall then exists at all flows below that for peak static-pressure ratio.

A wide variety of stall patterns may exist for single-stage compressors. There may be one or more stall zones around the axis of the compressor. As many as eight zones have been observed. In a given compressor, the number of stall zones usually varies with flow. These stall zones may extend over the entire span of the blade or only over a part of the blade span. They are generally equally spaced and of approximately equal size, but variations from this uniformity have been observed. The propagation rate varies appreciably, but is nearly always in the direction of rotor rotation. The abrupt or sudden stall of a large portion of the radial span of a blade row usually leads to an abrupt and discontinuous drop in pressure rise at the stall point. In contrast, progressive stall in which the stall zones grow gradually in circumferential and radial extent results in the continuous type of performance shown in Fig. 2. The abrupt type of stall is usually obtained in blade rows with a high hub-tip ratio, such as exit stages in the multistage unit. Progressive stall is usually encountered in the inlet stages with low hub-tip ratio.

In a multistage axial-flow compressor the variation of angle of attack for the individual blade rows is a function of the speed of the compressor and the location of the blade row in the compressor.

These variations in stage operating angles of attack are a result of compressibility, the fixed-area convergence through the compressor, and the fixed blade angles. At design speed, the air density in the rear stages is much greater than that in the front stages. Therefore, the annular flow area for successive stages is decreased as indicated in Fig. 3, so as to give the desired variation in axial velocity through the compressor. Fig. 3 presents a longitudinal view through a multistage compressor in which the area variation through the compressor was set so that the inlet and exit stages would operate at the design points circled on the stage performance curves at the bottom of the figure. The inlet- and exit-stage performance is presented in

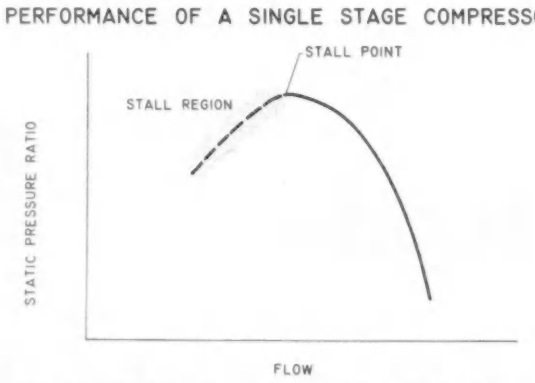


Fig. 2—In progressive stall, pressure ratio increases with flow only to a point, then drops off.

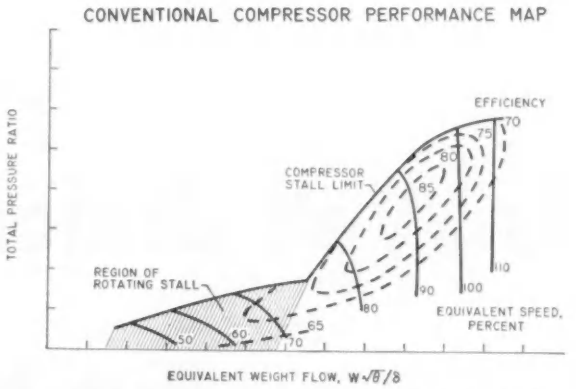


Fig. 4—At low speeds, rear stages suffer abrupt stall, causing front stages to approach progressive stall. Shading represents this region of operation.

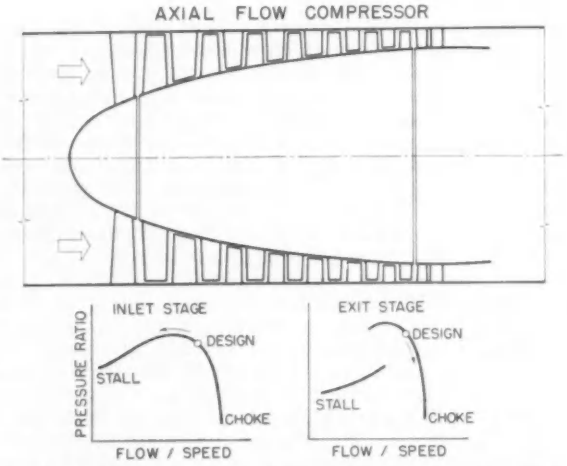


Fig. 3—Annular flow area decreases from stage to stage. At low values of rotative speed, flow area of rear stages is too small for flow induces by front stages. So rear stages choke. This flow restriction in rear stages causes front stages to approach gradual stall.

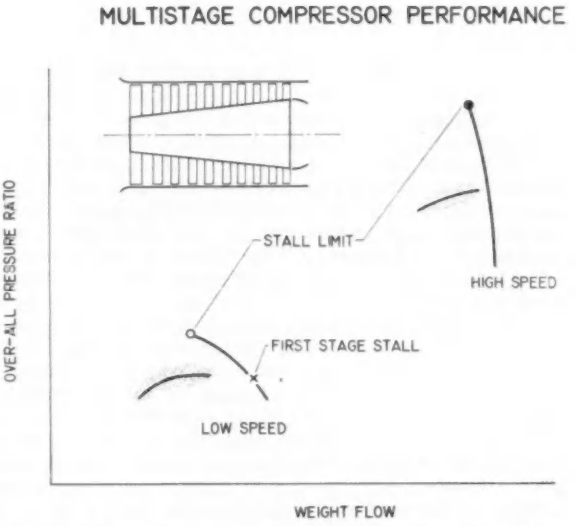


Fig. 5—Complete stall of a compressor is characterized by a sharp decrease in pressure ratio, whether it occurs at low speed or at high speed.

terms of an equivalent pressure ratio, which within certain compressibility limits may be considered to be independent of speed, varying the ratio of flow to speed.

At low values of rotative speed, the pressure ratio and the density ratio across the compressor are much less than for design rotative speed. As a result, the flow area of the rear stages of the compressor is too small and these rear stages choke as indicated by the arrow on the exit-stage curve. The flow restriction imposed on the rear stages at speeds below design speed causes the front stages to approach stall as indicated by the arrow on the inlet-stage curve. At sufficiently low speeds, inlet-stage stall is encountered and a rotating stall results. This region of operation is indicated by the shaded area on Fig. 4.

The reverse trend occurs as the speed is increased above the design speed. At high speed, the pressure rise through the compressor is greater than the de-

sign value so that the exit stages move toward stall while the inlet stages choke.

Increase in over-all compressor design pressure ratio results in greater over-all variations of flow area through the compressor and also greater variations of density ratio with speed. As a result, the inlet-stage stall generally extends to higher speeds for high-pressure-ratio compressors than for low-pressure-ratio units.

At Lewis Flight Propulsion Laboratory the rotating stall phenomenon at low speeds has been observed in practically all multistage axial-flow compressors in which measurements of unsteady flow have been made. The magnitude of the low speed rotating stall flow fluctuations generally increases through the first few stages and then decreases rapidly towards the rear of the compressor. However, definite flow fluctuations extend throughout the entire compressor.

As in single-stage compressors, a wide variety of rotating stall patterns has been observed in multistage compressors. The stall pattern may consist of from one to eight or more low flow zones around the compressor circumference. The number of zones depends on the operating condition of the compressor as well as on the compressor and engine design. In some compressors, several numbers of stall zones have been observed intermittently at a fixed operating point. These stall zones are generally concentrated at the tip of the compressor blades. However, in some designs the stall zones are concentrated at the hub, and in rare instances stall zones at both the hub and tip have been observed simultaneously. The stall zones are usually equally spaced around the circumference, but exceptions have been observed. The propagation rate of the stall zones varies from about 45 to 55% of rotor speed and propagation is in the direction of rotor rotation. No theories have been developed for predicting rotating stall characteristics for multistage compressors.

The existence of rotating stall in one stage of a multistage compressor does not necessarily result in large decreases in compressor performance. The low efficiencies normally observed at low values of rotative speed can generally be attributed to depreciation of stage performance due to off-design operation and stage mismatching rather than to the effects of the unsteady flow imposed by rotating stall. Although the local flow is unsteady when rotating stall exists, the net flow through the compressor is steady and stable operation is obtained.

In addition to rotating stall due to inlet-stage stall at low equivalent speed, another phenomenon called complete compressor stall is encountered at all speeds. This is also a form of propagating stall and is due to excessive angle of attack on one or more blade rows. These two phenomena are, however, appreciably different in their effects on over-all compressor performance. The effect of rotating stall on compressor performance is generally not of such a magnitude as to render the engine inoperable. On the other hand, complete compressor stall represents the minimum flow consistent with useable compressor operation at any given equivalent speed. Complete compressor stall is characterized by a sharp decrease in pressure ratio as shown in Fig. 5. This figure shows the pressure ratio characteristics for a low and a high value of rotative

THIS article is based on the papers:

"Are We Gaining on the Compressor Stall Problem?"
Maj. Alfred J. Gardner, USAF
Power Plant Laboratory, Wright Air Development Center

"Compressor Stall Problems in Gas-Turbine Type Aircraft Engines"
William A. Benser, Chief
and **Harold B. Finger,** Associate Chief
Lewis Flight Propulsion Laboratory, NACA

"Control Approaches to Solution of Compressor Stall"
W. A. Gebhardt, Manager of Fuel Systems Engineering and **R. Bodemuller,** Assistant Chief Engineer for Research and Development, Bendix Aviation Corp.

"A Customer's View of Turbine Engine Stall"
Maj. Kenneth L. Jones, USAF
Power Plant Laboratory, Wright Air Development Center

plus material in a talk

"Turbine Engine Stall from the Design Point of View"
J. S. Alford
Jet Engine Department, General Electric Co.

. . . and a discussion by
F. Schwoerer, Manager of Advanced Development, Westinghouse Aviation Gas Turbine Division

. . . and a session secretary's report by
J. D. Redding, Headquarters Sales Manager, Westinghouse Aviation Gas Turbine Division

The paper by Gardner was presented at the SAE Golden Anniversary Aeronautic Meeting held in Los Angeles in October, 1955. The other material was presented at the SAE National Aeronautic Meeting held in New York in April, 1956. The four papers are available in full in preprint form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. at 35¢ each paper to members, 60¢ each paper to nonmembers.

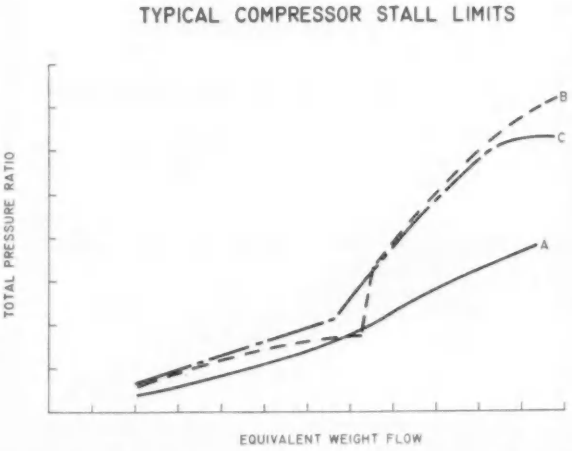


Fig. 6—Shape of the compressor-stall limit line varies from design to design. Curve A is typical of a low-pressure-ratio compressor. Curve B is for one high-pressure-ratio compressor, and Curve C is for another high-pressure-ratio compressor.

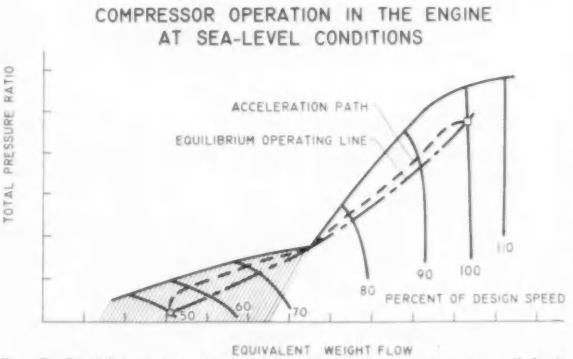


Fig. 7—Equilibrium operating line runs close to compressor-stall limit line—and acceleration path runs even closer. Problem is to design an engine control which will provide for engine acceleration without pushing compressor into stall region. Problem is particularly acute at "knee" of the stall limit curve.

speed. A large decrease in efficiency occurs along with the drop in pressure ratio shown in Fig. 5.

At high values of rotative speed, compressor stall is initiated by abrupt stall of the rear stages. As speed is decreased, complete compressor stall is instigated by abrupt stall of successively earlier stages. At very low speeds, compressor stall is probably instigated by the middle stages. The locus of the compressor stall points for all speeds comprises the compressor-stall limit line.

The flow required to unstall the compressor is somewhat higher than that at which stall is initially encountered. Thus, unstalling of the compressor exhibits a definite hysteresis effect. This effect is quite large at low speeds and is quite small at high speeds as indicated in Fig. 5. Therefore, unstalling, particularly at low engine speeds, requires a large reduction in fuel flow.

The complete compressor-stall phenomenon is also characterized by a low flow or stalled zone which rotates about the compressor axis. This stall zone is a region of practically zero flow or perhaps even reverse flow which generally extends over the entire span of the blade and covers one-third or more of the compressor circumference. Furthermore, the large deficiency of velocity in the stall zone is maintained throughout the entire length of the compressor. The stall zone rotates in the direction of compressor rotation, but at a speed slightly less than that for rotating stall instigated at low speeds by inlet-stage stall. When compressor-stall exists, the local flow is extremely unsteady. However, as for the case of rotating stall, the new flow through the compressor and the torque required to drive the compressor are steady.

The shape of the compressor-stall limit line is important in regards to flexibility of engine operation. Experience has indicated a wide variation of stall limit-line characteristics. Some typical stall limit lines are shown in Fig. 6. This figure is a plot of compressor-stall pressure ratio against equivalent weight flow for several compressors. Curve A is typical of a low-pressure-ratio compressor and shows a fairly continuous variation. Curve B is for a high-pressure-ratio compressor and shows a very abrupt dip at intermediate values of equivalent flow. This dip is closely related to stalling of the inlet stages of the compressor.

Curve C (Fig. 6) again represents a relatively high-pressure-ratio design. In this case the stall limit line at low speed is approximately linear. At some intermediate speed, the slope of the stall limit line increases appreciably. Thus, a change of slope occurs for curve C, but this stall limit line does not have the severe dip that is indicated for Curve B. For speeds above the design value, the slope of Curve C is practically zero.

High-pressure-ratio compressors have rather severe stall limitations at low and intermediate speeds. Some high-pressure-ratio units have large dips at intermediate speeds. Other units have the double slope characteristics indicated by Curve C. Some compressors have a definite leveling out of stall pressure ratio at high speeds. Others continue to increase stall pressure ratio, even at speeds appreciably above the design value. The particular characteristics for a given compressor are determined by the basic stage characteristics and by the matching of stages. Currently, however, the stall limit characteristics of a compressor cannot be analytically determined from the geometry of the design, but must be determined experimentally.

The Factors that Aggravate Stall

The operating altitude of the engine affects its stall-free operating range. A general index of conditions in which the engine must operate is a Reynolds number index. As altitude increases, Reynolds number decreases and although the effect

varies with engine sizes and types it may be generally said that as Reynolds number decreases with increased altitude above design altitude, that the margin between stall and operating lines decreases. This is due to the change in boundary layer conditions and flow Mach numbers over the compressor blades.

Compressor inlet temperature affects stall margin through the temperature effect on equivalent engine rpm. In addition, the stage matching problem is aggravated if the compressor must operate over a wide range of inlet temperatures. Stages are matched for certain design point inlet Mach numbers and weight flows. As inlet temperature changes, the compressor is forced to operate in off-design conditions which affect the stall margin in proportion to the deviation from the design point conditions for which the stages were matched. The range of off-design conditions which the compressor can tolerate without stall tends to decrease as pressure ratio of the compressor increases.

Inlet flow distortions reduce the design-point stall margin. Distortions occur in many ways. First, the inlet duct design may cause flow separation or turbulence due to too rapid diffusion, sharp bends, or other irregularities of design or production. Operation of the duct at severe off-design flight speed conditions may lead to distortion of flow. Flow separation can also result from excessive angles of attack of the incoming air on the inlet rim. Whatever the source of the pressure and velocity distortions of the engine inlet air, the final result is a reduction of stall margin.

Where velocity falls below design, the angle of attack on the first stage is increased and stall may occur. In the regions where velocity is above design, the first stage angle of attack is reduced which may lead to overloading of rear stages and stall. Experimental evidence to date indicates that distortions may be radial or circumferential, that they tend to continue on through the compressor, and that they seriously reduce stall margin or actually prevent stall-free engine operation. The problem may manifest itself in ideal flight conditions as a result of duct and compressor designs or may be encountered as a result of the effects of flight attitude and maneuvers.

The Problem of Accelerating the Engine

A typical fixed-geometry compressor performance map is presented in Fig. 7 for sea-level conditions. The heavy dash-dot line indicates the steady-state or equilibrium operating line of the compressor when installed in a fixed-geometry engine. This line is determined by the matching of the compressor with the other components of the jet engine. It might be considered that the other components act as a throttle on the compressor to force the compressor to operate at a given point at each speed. The locus of these points is then the equilibrium operating line and indicates the pressure ratio and flow of the compressor at each engine speed.

The design-point pressure ratio of the engine is indicated by the square symbol in Fig. 7. In order to obtain minimum fuel consumption, the turbine and exhaust nozzle are generally sized so as to cause the compressor to operate at as high a pressure ratio as is consistent with good compressor efficiency. The efficiency contours on Fig. 1 indicate that to achieve maximum compressor efficiency at design speed, the operating point must be relatively close to the stall limit line.

In order to bring the engine up to the design point, the starter runs the engine up to approximately 30 or 40% of design speed. Fuel is then ignited in the combustor, the starter disengages, and the engine speed increases to the idle speed (about 50% of design speed). The idle speed operating point is indicated by the circled point on the equilibrium operating line in Fig. 7. This point is generally in the rotating stall region.

Acceleration from idle speed to design speed is accomplished by injecting and burning more fuel in the combustor than is required for constant speed operation. The resulting increase in turbine temperature forces the compressor to operate along a path such as that shown by the dashed line (Fig. 7). Thus, the acceleration path lies closer to the compressor stall or surge region than the equilibrium operating line. For mechanical reasons, it is, of course, desirable to accelerate as fast as possible out of the rotating stall region where blade vibrations are probable. For operational reasons, it is also essential that rapid engine acceleration be obtained. Rapid acceleration requires large and rapid increases in fuel flow and turbine-inlet temperature. The magnitude of these fuel and temperature increases is generally limited by the margin between the equilibrium operating line and the stall line. The wider this stall margin, the more fuel that can be added and the faster the acceleration. Of course, in certain cases, it is conceivable that the margin for acceleration may be so great that the boost in fuel flow may be limited by the allowable engine temperature level rather than by the compressor-stall line. Such a condition is, however, unusual and would be the exception when we consider acceleration from idle to design speed.

If the stall margin is so small that the acceleration path moves into the compressor-stall region, then the engine generally will not accelerate. In such a case, combustion blowout may result from the unsteady flow condition encountered in the compressor-stall region, or an engine failure due to excessive temperatures may result. Even if the compressor does operate stably at flows below the compressor-stall flow at a given speed, the performance in this region is generally so poor that excessive turbine temperature would be required even for steady-state operation. Thus, any attempt to accelerate through this region would probably result in an engine failure.

For the stall limit line shown in Fig. 7, a reasonable margin exists in the range of 50 to 70% speed. The margin is extremely small at about 75% speed where the slope change in the stall limit line occurs. At speeds above 75% speed, an appreciable stall margin is again available. In compressors that show a large dip in the stall limit line, such as shown on curve B of Fig. 6, the stall limit line may actually intersect the equilibrium operating line. In this case, acceleration to design speed would be impossible without the aid of some variable geometry features such as exhaust-nozzle adjustment or air bleed.

One of our major problems is, therefore, to provide

sufficient margin between the equilibrium operating line and the compressor-stall line at all speeds so as to permit satisfactory engine acceleration.

The Job of the Engine Control

The major problem in acceleration control of a turbine engine is to keep the acceleration line safely between the steady state line and the stall-surge line. There are three ways to do it:

1. Scheduling, or open loop, control.
2. Closed-loop control using compressor parameters which synthesize the stall boundary.
3. Closed-loop control using an incipient stall 'sensor'.

Fig. 8 shows an elementary block diagram which illustrates the scheduling stall control. Nearly all gas turbine engines currently in production are controlled in this manner. As illustrated, suitable compressor parameters are selected from the compressor performance map, and are functionally related to define the stall and surge boundary. It is obvious from viewing the compressor map that the stall boundary may be defined by any two of the three compressor parameters—namely, pressure ratio, air flow, and engine speed—provided that the compressor stall limit can be, and remains, rigorously defined as shown on the compressor performance map.

However, the scheduling control must compute the metered fuel flow which, when burned in the combustor, will provide this correct relationship between the selected compressor parameters.

Schedule type control systems, based on experimentally determined stall and surge lines, have thus far afforded the best practical protection against surge during acceleration. But schedule controls are far from being completely satisfactory because of the unpredictable variations in the stall lines from engine to engine, or even on the same engine. In order to insure a safe stall schedule for the worst condition of operation, it has been necessary to sacrifice acceleration in operating ranges where greater engine accelerations would otherwise be permissible. In some cases the margin between the fuel flow producing stall and the fuel flow required for steady state is so small that reducing the acceleration schedule sufficiently to be safe from stall under all conditions will result in engine "hang-up"—which is the phenomenon resulting when the accelerating fuel flow schedule becomes equal to the steady state fuel flow and the engine will not continue to accelerate.

In Fig. 9 is illustrated the control of compressor stall by the use of a closed loop control. In this type of control, an appropriate compressor stall parameter, which defines the stall boundary, is requested by the control. The control senses the related compressor variables and compares the magnitude of the requested parameter with the sensed parameter. The resulting error in magnitude of the parameter is amplified, and is used to vary fuel flow until the error is reduced to zero. In effect, this means that the physical character of the fuel, combustion efficiency, and combustor time response can now be treated such that these factors do not produce inaccuracies in the stall control.

Parameters will define stall for a well-behaved compressor. Thus, the stall boundary may be defined by a relationship between pressure ratio and corrected speed.

In a similar manner, corrected turbine inlet temperature as a function of corrected engine speed will approximately define the stall boundary. Or stall boundary can be approximated by limiting the

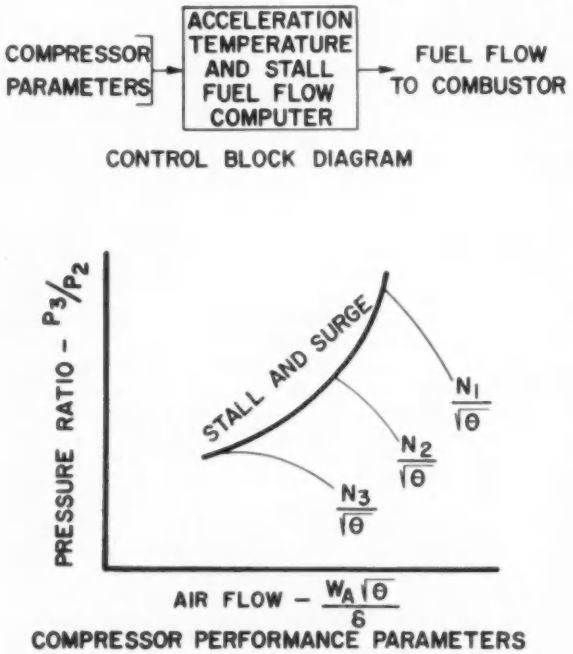


Fig. 8—Block diagram of scheduling stall control and (below) plot showing compressor parameters which may be used for control.

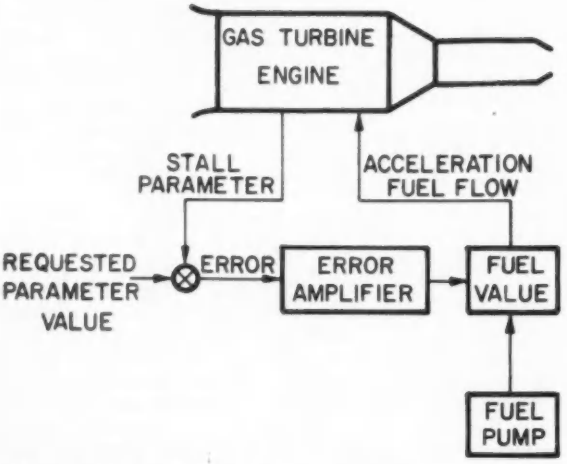


Fig. 9—Closed-loop control of compressor stall.

engine acceleration rate as a function of corrected engine speed.

Other combinations of compressor functions have been studied and some have been experimentally investigated. However, the parameter selected to define the stall boundary for this type of stall control is still a synthesis, or an empirical definition, of stall and surge. It is important to note that effects such as inlet duct distribution and engine variations in production can not be detected by this method of stall control. Even more important, the new types of engines now in the design and development stages afford negligible empirical data regarding compressor stall and surge.

The main advantages of the closed loop control are (1) the possibility of providing excellent flexibility and adjustability, in order that the correct control settings can be rapidly explored for the experimental engine, and (2) the elimination of effects due to changes in physical properties of fuel, which is a significant variable in this problem.

For these reasons, research is progressing to develop a closed loop control using an incipient stall sensor. The concept of a stall sensing device appears to offer a better solution than any other. As an integral part of the engine power control system, the stall sensor could alleviate most, if not all, of the harmful effects of a stall or surge. Even if it should initially take the form of a stall limiter capable of limiting the surge to a minimum number of cycles, most of the harmful by-products would be removed.

A single surge cycle occurs over such a short time period that the effects of blade stresses, turbine overtemperature, and thrust deterioration would be minimized.

In the search for a stall sensing device, the overall performance parameters of the compressor, individual stages, or other engine components have already been thoroughly examined. There has been little success in finding a parameter that gives the desired stall warning. Probably the next step is to go beyond these overall parameters and search for detail phenomena that may give an indication of incipient stall. The occurrence of rotating stall may be the answer. Or the answer may lie in local boundary layer separation or velocity profiles in critical portions of the compressor.

The Fixes

Until a stall sensor is developed—and to lighten its burden when it is—there are some means available to lessen the stall problem:

1. To a certain extent, the engine may be removed from its single-design-point category by varying flow areas throughout the engine. Inlet guide vanes, compressor stators, bleed ports, turbine nozzles, and jet exhaust nozzles all offer means of adjusting flow areas for a portion of the engine, and thus for a portion of the operating range. Modulation of these flow areas can provide a broader stall-free operating range. However, the gain will probably be at the expense of additional complexity and weight.

2. Variable geometry inlets can help in the same fashion as variable flow areas within the engine. This is particularly true in view of the much expanded operating range required of today's gas turbine engines. The extreme altitudes and flight speeds required to satisfy mission performance objectives force the turbine engine to operate in a medium foreign to its design. In a similar manner, high rates of climb and high combat maneuver loads subject the engine to severe transients. Inlets which mechanically or aerodynamically compensate for changes in flight Mach numbers and angles of attack and yaw could materially aid in reduction of the stall problem. Another factor which might be of help is the integration of variable component controls into the basic engine power control system.

3. The airframe ducting, or that portion which affects the operation of the engine, offers another medium for partial alleviation of the problem. Experience has shown that improper distribution of the engine inlet air can cause a severe depression of the engine stall limit line. This has been the subject of many technical meetings and the magnitude of the problem is now generally known. Compromise between external drag characteristics, structural requirements and internal flow passages is always a necessity in design of the airframe. However, proper emphasis should be placed on designing and producing a duct which will deliver the best flow profiles attainable. Again, the control of production tolerances is of utmost importance. Even the small duct distortions traceable to production may produce significant flow disturbances and thus contribute to engine stall.

4. The placement of external stores and armament is also of interest in this field. Armament firing has been the cause of flameouts in some cases, and stall or surge in others. The transient pressures and temperatures due to firing of armaments are quite severe and probably both contribute to the troubles encountered.

5. Better control of production tolerances can alleviate stall tendencies. Dimensions are critical in all gas turbine engines, with variations in criticality produced by basic design features and the materials used. In some engines, the compressor rotor blade to case clearance is extremely critical with respect to design weight flow and consequently design net thrust. In others, the axial spacing of the compressor rotor with respect to the stator is of major significance. An axial shift of very minute proportions has been known to produce compressor stall. In a blade row operating close to the stall line or pumping limit an axial shift of the rotating blades can produce a change in relative wind sufficient to stall the blades.

Again where a blade row is operating close to its pumping limit, local flow perturbations produced by the preceding stage, or small contour differences between blades in a given row can produce the progressive condition of rotating stall. There are many other examples of the detrimental effects of dimensional changes.

In a general sense, the same ideas may be applied to the production of power control systems. Sensing elements, signal amplifiers, and metering components all have their individual roles to perform in the operation of the engine. Production variations

may change the characteristics of any or all of these components sufficiently to effect a loss in stall margin. These same variations, coupled with like changes in the engine, and further aggravated by installation or operating conditions, are almost certain to cause trouble.

Of course, anything the engine manufacturer can do to raise the stall line will aid in the solution of the problem. The two most widely known methods of accomplishing this are the twin-spool type of design and variable-angle stator vanes in the compressor. It's up to the engine manufacturer also to provide a means for reducing engine speed rapidly when stall is encountered.

Redesign of the T56 Turboprop Compressor Gives Freedom from Stall and Improves Performance

Excerpt from discussion by
L. B. Lisher,
Allison Division, GMC

Due to the more complete expansion in the turbine, the cycle analysis of the turboprop shows that the optimum pressure ratio is below that of a subsonic turbojet. Using present turbine temperature limits and component efficiencies, a pressure ratio of about 12 to 13 gives about optimum performance for cruise at 35,000 ft. for a turboprop. This would be somewhat over the pressure ratio of peak power output but have lower specific fuel consumption. The Allison T56 operates at a pressure ratio of about 11¼:1 at this condition.

Due to lower ram, the corrected speeds for the compressor are much higher for the turboprop than for the turbojet. However, the idle speed requirements for the turbojet are much different. The turbojet idles at about 40% to 50% speed, whereas the turboprop usually idles at a much higher speed, about 95% rated speed for the Allison T56 military engine.

Therefore, the required operating range of the turboprop, except for starting, lies in the corrected speed range of 87% to 112% of rated speed for hot day to high altitude operation.

Because of propeller problems and size requirements, the turboprop engines are in general much smaller in size than the modern turbojet engines. The present T56 turboprop has a compressor tip diameter of less than 15 in. This small size presents many other associated problems to the compressor designer—such as low Reynolds number and critical radial clearance problems. Due to the high corrected speeds and the low Reynolds number resulting at altitude, it has been necessary to match the compressor for best performance obtainable at altitude. However, by so doing, the surge curve was naturally worsened. Therefore, the final product is a compromise between these two extremes.

The radial seal clearances were found to represent considerable performance losses and also large depressions in compressor surge range. Therefore, every effort has been made on Allison turboprop engines to reduce these clearances to the minimum at both the rotor tips and at the interstage vane seals.

Allison has used compressor bleeds to provide sufficient margin for starting and acceleration in the low speed range. In general, rotating stall occurs only at the high pressure ratios just prior to surge. For the commercial versions of the Allison turboprop, idle speed will be lowered to about 75% speed, which will still be above the rotating stall range.

The 14 stage axial flow compressor was originally designed to have an airflow of 30 lb per sec at a pressure ratio of 8.5:1 for sea level static conditions with an operating speed of 14300 rpm.

Initial component testing revealed that design airflow was attained, that the operating pressure ratio could be 9.5:1 instead of 8.5:1, and that the compressor had an unusually smooth and favorable surge line for a high pressure ratio machine.

Although the compressor map as such appeared encouraging, two conditions unfavorable to engine performance became apparent. First, the peak efficiency occurred at 85% speed, which would be bad for altitude performance, and secondly, the airflow tended to level off at slightly over 30 lb per sec, which also hurt altitude performance.

To correct these unfavorable conditions, compressor stages were rematched to better suit the engine requirements. The re-staging was done by changing the setting angles throughout the compressor in order to move the match speed to a higher value. Interstage seal leakage was also reduced at the same time.

This re-staged compressor improved both altitude and sea level performance by pumping considerably more airflow and had the peak efficiency island moved up closer to normal operating speeds. The surge line at low speeds was, of course, lowered, but good starting and accelerating characteristics were obtained by bleeding air from two of the compressor stages. This compressor was used on pre-production (YT56) engines.

A redesigned first stage taking full account of radial flow considerations was then substituted for the original first stage. This fattened up the surge line at the critical bleed closing speed range (12,000–13,000 rpm) so that the match speed could be moved still higher by resetting the inlet guide vane. This compressor had a peak capacity of nearly 36 lb per sec and peak efficiency occurred very close to the sea level operating point. This compressor is used on the T56 engine. A slight increase in mid-stage bleed was necessary since low speed surge was adversely affected by these changes.

Airflow, surge pressure ratio, and efficiency have all been improved by comparison with the original design at the high corrected speeds. The gains at these high corrected speeds would have been impossible without some means of offsetting the associated losses in the starting range. Fortunately, the dual starting bleed is so beneficial that starting acceleration is better by far with the T56 compressor than with the original design without bleed.

The Small Gas Turbine

The Small Gas Turbine Cycle and Exhaust-Heat Recovery

Based on paper by

A. A. Hafer

General Electric Co.

FUTURE small gas turbines will employ a regenerative cycle. The economics of heat recovery demand this arrangement. Besides its use for regeneration, however, gas turbine exhaust will be used:

1. For liquid heating.
2. For steam generation.
3. As preheated combustion air.
4. For ventilating small engine compartments.

The basic cycle which will be employed extensively in the future for small gas turbines is the regenerative cycle, as shown in Fig. 1, for a two-shaft arrangement. Here, the heat remaining in the turbine exhaust preheats the combustion air between the compressor discharge and the combustion chamber. By using a regenerator to transfer part of the energy remaining in the gas turbine exhaust to the combustion air, gas turbine powerplant efficiency improves by as much as 30 to 35%.

It is possible, too, to use the exhaust from a simple-cycle gas turbine to preheat feedwater for various types of processes or boilers, or to **heat** other types of **liquids** in refineries and similar applications. The exhaust of a 1000 hp simple-cycle gas turbine contains about 8,000,000 Btu per hr of recoverable energy. If this energy is recovered to heat some type of liquid, such as boiler feedwater, the resultant overall gas turbine powerplant efficiency may be as high as 60%, when credited with the heat added to the feedwater. Simple types of tubular heat exchangers can be used for recovering this exhaust energy.

Another very advantageous application for using the energy of a simple-cycle gas turbine is to **generate steam** for process or heating purposes. Simple waste-heat boilers are used for this type of application.

When the gas turbine exhaust is used to generate process steam, and the turbine is credited with the heat transferred to the steam, an overall gas turbine powerplant efficiency of as high as 60% can be obtained. Since many applications require process steam as well as power, the gas turbine will frequently be the most economical prime mover available.

About 85% of the oxygen originally contained in the air compressed in the gas turbine still remains in the gas turbine exhaust. Therefore, the gas turbine exhaust can be used as highly **preheated combustion air** in combustion processes such as for a boiler.

When the steam boiler is sized to use all of the available oxygen in the gas turbine exhaust, the gas turbine represents about 15% of the combined plant output. In other words, a 1000 hp gas turbine provides sufficient combustion air for a 5700 hp steam turbine, with a resultant combined plant output of 6700 hp. This combined plant will have a thermal efficiency 5–7% better than the base steam plant. So, this type of cycle is extremely attractive from a thermodynamic standpoint.

The solution to the problem of **ventilating small, hot engine compartments** is contained within the gas turbine itself. Exhaust gas velocities in the

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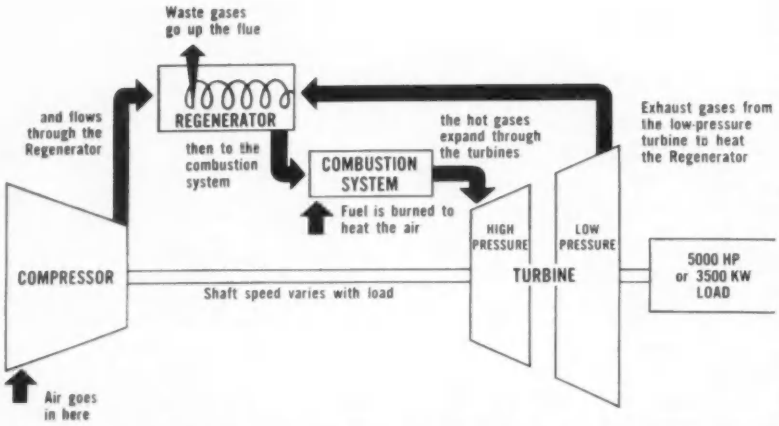
Waste gases go up the flue
REGENERATOR
and flows through the Regenerator
then to the combustion system
COMBUSTION SYSTEM
the hot gases expand through the turbines
Exhaust gases from the low-pressure turbine to heat the Regenerator
Fuel is burned to heat the air
HIGH PRESSURE
LOW PRESSURE
COMPRESSOR
TURBINE
5000 HP or 3500 KW LOAD
Shaft speed varies with load
Air goes in here

Fig. 1.—Future small gas turbines will employ a regenerative cycle. Gas turbine efficiency improves by as much as 35% with this type of arrangement.

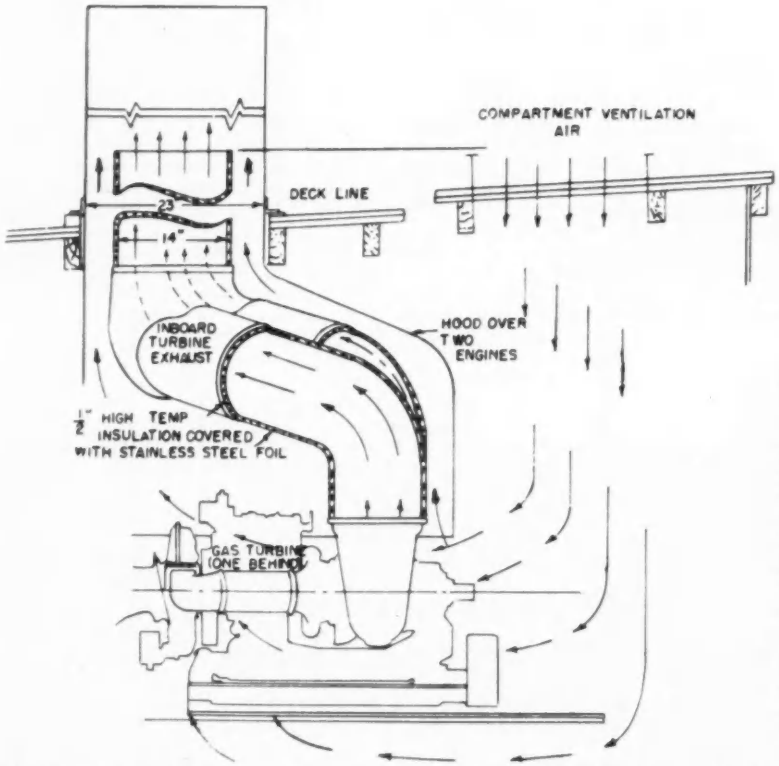

Fig. 2—Gas turbine stack ejector systems provide a means of ventilating hot engine compartments. Air is drawn into the engine air casing from the compartment by the ejector effect of the exhaust gases and is passed on out the stack.

stack of a typical small gas turbine may be from 200 to 300 fps. By using the energy in this exhaust gas, it is possible to both provide a path for the engine heat to escape from a small compartment and simultaneously ventilate the compartment.

This is accomplished by fitting an air casing around the gas turbine joined to another stack surrounding and extending above the gas turbine engine stack, as shown in Fig. 2. Air is drawn into the engine air casing from the compartment by the ejector effect of the exhaust gases and is passed on out the stack.

Tests conducted at the U. S. Naval Engineering Experiment Station at Annapolis indicate that this ejector system is ideal for use with small gas turbines in a restricted machinery space. In these particular tests, a total gas turbine airflow of 14 lb per sec (34,000 cfm at 1200 F) induced a ventilation airflow of 7400 cfm. When it is noted that the exhaust gases from these machines was at 1200 F and that the average outer stack temperature above the machinery space was only 120 F, the effectiveness of this system can be appreciated.

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Heat Exchangers for Small Regenerative Gas Turbines

Based on paper by

Dr. W. W. Chao

Ford Motor Co.

THE future of the small regenerative gas turbine depends on the compactness of its heat exchanger. Therefore, the problem of selecting engine design variables to facilitate the reduction of heat exchanger size is of vital importance. The contra-flow rotary regenerator and the cross-flow recuperator are two of the more promising heat exchanger types for small gas turbines.

The simple open cycle gas turbine with exhaust heat regeneration seems very promising as a competitor of reciprocating engines for land and marine applications. A major prerequisite of such a powerplant, however, is a compact heat exchanger.

The efficiency of a simple open cycle gas turbine must be raised if it is to compete with the lower specific fuel consumption of the reciprocating engine. Regeneration does the job here. For small power units, however, such improvement must be accomplished with a minimum amount of mechani-

cal complexity and weight penalty, so that the power package as a whole can be competitive. Here's where compactness of the heat exchanger becomes part of the picture.

With the introduction of a heat exchanger, the characteristics of a gas turbine powerplant are quite different from those of a turbine without regeneration, and a new set of design criteria results. To achieve an efficient overall powerplant design, one must carefully evaluate the matching characteristics of the various components involved, namely, the heat exchanger, compressor, combustion chamber, turbine, and ducting system. Such design optimization usually differs from one powerplant to another, depending upon the particular application involved.

The effects of leakage and engine pressure loss factor, in relation to the conditions of minimum flow and minimum regeneration, and the corresponding pressure ratio requirements must be considered. In general, the minimum flow and regeneration required decrease with the engine pressure loss factor, which is, of course, favorable to heat exchanger size. However, in order to achieve compactness, a sufficient part of the engine pressure loss factor must be apportioned to the heat exchanger gas side pressure drop. Therefore, the importance of careful aerodynamic design to reduce pressure losses through the ducting cannot be over-stressed.

Two promising types of heat exchangers are the contra flow rotary regenerator and the cross-flow recuperator. For a given heat transfer surface and Reynolds number selection, the rotary regenerator dimensions are affected by the required airflow, W, efficiency, η_h, and the gas side pressure loss limit, $\Delta p'$,

$$\text{Frontal area} \sim (W) \cdot \left(\frac{\eta_h}{1-\eta_h}\right)^{\frac{1}{2}} \cdot \left(\frac{1}{\Delta p'}\right)^{\frac{1}{2}}$$

$$\text{Volume} \sim (W) \cdot \left(\frac{\eta_h}{1-\eta_h}\right)^{2} \cdot \left(\frac{1}{\Delta p'}\right)$$

$$\text{Weight} \sim (W) \cdot \left(\frac{\eta_h}{1-\eta_h}\right)^{\frac{3}{2}} \cdot \left(\frac{1}{\Delta p'}\right)^{\frac{1}{2}}$$

and for the cross-flow recuperator,

$$\text{Volume} \sim \left(\frac{1}{K_c}\right)^{2} \cdot (W) \cdot \left(\frac{\eta_h}{1-\eta_h}\right)^{2} \cdot \left(\frac{1}{\Delta p'}\right)$$

$$\text{Weight} \sim \left(\frac{1}{K_c}\right)^{\frac{4}{3}} \cdot (W) \cdot \left(\frac{\eta_h}{1-\eta_h}\right)^{\frac{3}{2}} \cdot \left(\frac{1}{\Delta p'}\right)^{\frac{1}{2}}$$

where K_c is the cross-flow factor.

For given performance requirements and heat transfer surface, the size of the heat exchanger increases rapidly with Reynolds number. The latter, however, has little effect on flow area. Whereas the rotary regenerator can take full advantage of low Reynolds number design, the minimum value of Reynolds number that can be used for cross-flow recuperator design is limited by the length that is available in the no-flow direction. For a given heat transfer surface, Reynolds number selection, and performance requirement, the necessary recuperator no-flow length also increases linearly with flow. So, whereas the cross-flow recuperator merits serious consideration for small flow machines, rotary regenerators must be used when power requirement is above a certain level.

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Design Requirements of a Good Combustion System

Based on paper by

H. A. Fremont and Dr. S. N. Suciu

General Electric Co.

A GOOD combustion system design requires that the system:

1. Burn as much fuel as possible.

2. Operate with low total pressure loss.

3. Maintain uniform and controllable turbine inlet temperatures.

4. Maintain continuous combustion.

5. Be compact.

A good combustor operates at high

Chairmen of the three sessions of the symposium were:

W. H. Byrne
President, Byrne Associates

B. Pinkel
Head, Material & Thermodynamics Research Division, NACA

R. R. Peterson
Head, Gas Turbine Section, Bureau of Ships, Navy Department

Members of the program committee were:

Chairman
Jerome Bartels
Associate Professor of Mechanical Engineering, Polytechnic Institute of Brooklyn

Philip Chaikin
Assistant Professor of Mechanical Engineering, Polytechnic Institute of Brooklyn

Herman Grau
Assistant Professor of Mechanical Engineering, Polytechnic Institute of Brooklyn

Clifford Wojan
Associate Professor of Mechanical Engineering, Polytechnic Institute of Brooklyn

efficiency, burning as much fuel to completion as possible within the confines of the system. This fuel economy is of the utmost importance in aircraft applications, of course, but no more so than in any other contemplated use of a gas turbine.

Also, in order to have high thermodynamic cycle efficiency, the combustor must operate with a very low total pressure loss. This usually is considered as being 3–6% of compressor discharge total pressure maximum.

The temperature of combustion gases entering the turbine area should be uniform and controllable. The design stresses present in turbine components, together with the lack of suitable high-temperature materials, limit allowable combustor exit temperatures to relatively low levels. If the combustion gas consists of regions of widely varying temperatures, premature bucket failures result, or else the engine output may be reduced by the necessity for operation at unnecessarily low average turbine inlet temperatures.

Combustion, of course, should be continuous. Ignition and reignition should be fast and simple, and operation should be stable over a very wide range of operating conditions ranging from ground starting to relight at altitude after flame-out.

The combustor should be compact. Length is especially critical because of the need to keep engine shaft length down to simplify design and minimize weight. And, obviously, the combustor should be simple to manufacture, install, maintain, and replace.

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Vibration In Gas Turbine Engines

Based on paper by

H. C. Hill
Boeing Airplane Co.

RELATIVELY large bearing clearances reduce gas turbine engine vibration. The large clearance permits the rotor to shift its rotational axis from the shaft center to a true balance center with no loading on the bearing and, as a result, little vibration of the turbine.

The gas producer rotor used in the 175 hp Boeing gas turbine runs at 36,000 rpm rated speed and is mounted on three bearings—a ball bearing at the compressor end, which takes the thrust, and two floating sleeve bearings, one near the center of the shaft and one at the turbine end.

The sleeve bearing has proved to have remarkable reliability and endurance characteristics. The reasons for this were not fully apparent until recent rotor-balancing studies disclosed that the double clearance in the floating sleeve is sufficient to accommodate a relatively large unbalance without excessive loading on the bearing. In other words, the bearing clearance is large enough to allow the rotor to shift its rotational axis away from the shaft center to the true balance center. It has been found, for instance, that the turbine bearing suffers no distress with a turbine blade missing, a condition which results in a bad out-of-balance of the turbine wheel.

The relatively close clearances of antifriction bearings promote very high loads from relatively small amounts of unbalance, at the high speeds required in small turbines. Even 1 in.-oz of unbalance, for example will cause a bearing load of 2200 lb at 36,000 rpm, if there is no clearance in the bearing. But if the bearing clearance will permit a shift of 0.005 in. in the rotational axis of the journal, then the rotor can remain in running balance with no loading on the bearing in spite of the 1-in.-oz balance error.

The rotor of a later engine model, the 502-10, runs at the same speed of 36,000 rpm but the impeller and turbine wheels are somewhat larger and heavier to provide the pressure ratio and improved efficiency of this engine. Fuel consumption has been reduced 25% and power increased a corresponding amount.

The center and turbine bearings on this rotor are the same as the one previously described. The ball thrust bearing adjacent to the compressor, however, becomes a more difficult problem here because of the higher thrust loads. So also is the rotor balancing more critical to avoid radial overloads in the ball bearing and corresponding high frequency vibration of the engine.

Even with precision-type ball bearings, practical manufacturing tolerances give up to 0.0002-in. runout of the inner ball race and another 0.0002 in. in the outer race. At 36,000 rpm this runout tolerance can cause a 600 c vibration of the engine structure of 14 g magnitude. Just how serious this is we do not know, and it should be understood that even with this vibration the engine by all previous standards runs quite smooth.

We do know, however, that engines with vibrations in the neighborhood of 40 g amplitude suffer fatigue cracking failures of burner shells, burner liners, nozzle tie rods, spark plugs, heat shields, and other sheet metal parts. Thus, a vibration tolerance in the neighborhood of 10 to 20 g is indicated for production engine acceptability.

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Gas Turbine Transmissions

Based on paper by

L. Kingston
Vertol Aircraft Corp.

GAS turbine drive systems must:

1. Reduce turbine speeds.
2. Cope with varying characteristics of the prime mover.
3. Adapt to the peculiarities of the power absorber.

The drive system of a gas turbine must reduce turbine speeds of 12,000 to 15,000 rpm to final output speeds of 100 to 500 rpm in the case of marine drives, to about 1500 rpm for fixed wing installations, and to 150 to 400 rpm in the case of helicopters.

The drive system has to cope with the varying characteristics of the prime movers—starting conditions, accelerations, torsional vibrations, and idling characteristics for instance.

The drive system must also adapt itself to the peculiarities of the power absorber. For example, the drive system of ground vehicles must cope with loads arising due to grades, sudden obstacles, or slippage.

As an example of some of the problems that a drive system faces, let us look at some of the requirements of a helicopter drive system installation. To complicate matters right from the start, power must be divided to two rotors. The power may be derived from one or more prime movers. The rotors must be kept in perfect synchronization by the drive system. A very substantial speed reduction must be accomplished, and the torque vector must be changed in direction.

In addition, the drive system must transmit lift, drag, and moment of the rotors into the structure of the helicopter. A helicopter is suspended by its transmission. The transmission must incorporate a free wheeling device to permit the helicopter to autorotate in case of power failure—this is equivalent to gliding of fixed wing aircraft—yet it must keep the rotors phased. The drive system must also provide a clutch which permits the gradual synchronization of prime mover to rotor, because it is only with the extra stiffening due to centrifugal

force that the rotor blades are strong enough to withstand full engine torque.

From this example it is obvious that a designer must consider all phases of the drive problem if he is to design a lighter, cheaper, and more reliable transmission.

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Small Turbojet Engine Control Requirements

Based on paper by

L. E. Berggren
Minneapolis-Honeywell Regulator Co.

SMALL turbojet engine controls are expected to supply:

1. Steady-state control.

2. Acceleration and deceleration control.

3. Auxiliary control.

The steady-state control should govern the engine at the speed selected by the power lever with no significant shift in set point resulting from changing engine inlet conditions. Such a requirement is quite reasonable. However, a jet engine is sensitive to inlet air density, in other words, inlet air temperature and pressure. As the inlet air density changes, the engine airflow and the required fuel flow also change. A simple proportional fuel control in which the fuel flow is reduced as engine speed increases does not give a constant engine speed under these conditions. The shift in engine speed, as inlet air density changes, is undesirable.

An isochronous control, employing integral action with rate stabilization, is believed to show the most promise for this application. The three terms should be defined for the sake of clarity:

- isochronous control—single speed control having, as applied here, a single speed for each position of the power lever.
- integral action—condition where metering valve is driven in the corrective direction at a rate proportional to the sensed error.
- rate stabilization—steadying of the control loop by sensing the rate at which the engine is changing speed and adding the resultant signal to the integral control signal.

The acceleration and deceleration control should govern the fuel flow during either acceleration or deceleration to give the best possible engine response with no engine malfunction resulting from surge, overtemperature, or flame-out.

Several methods of sensing the boundary limits during acceleration and deceleration have been investigated. One of these, using turbine discharge temperature, has been considered very seriously and a control has been built on this principle. This approach will work and does have some advantages; however, at present, it is too complicated to apply to a small gas turbine control.

Another approach to handling the part of this problem relating to engine surge uses compressor pressure ratio as the signal input. For the engines investigated, this parameter proved to be unsatisfactory. The observed changes in signal going from no surge to surge were too small for satisfactory control. No satisfactory method has yet been devised for directly sensing the approach of surge. Such information, if available, would greatly simplify the surge control problem.

Considering directly the small engine control, it appears that the lightest and smallest control results from scheduling acceleration and deceleration limits as a function of engine speed, inlet temperature, and inlet pressure. Of course, this approach to the control problem is not without its troubles. Unfortunately, the engines are not consistent in their performance, nor does this performance remain constant with engine life. Thus, a good control should provide adequate adjustment features, so the acceleration schedules can be set for best performance.

In any given control some of the following auxiliary or secondary control features will also be required:

1. Maximum steady-state turbine discharge temperature limiter

2. Maximum compressor pressure limiter

3. High corrected speed limiter

4. Fuel density compensation

5. Fuel heating value compensation

6. Fuel temperature compensation

7. Variable controlled engine idle speed

8. Minimum fuel flow

9. Positive fuel cut-off

10. Actual or corrected speed signal or both

11. Emergency control.

A good control from a functional or performance standard must also incorporate produceable components. This, of course, bears directly on a second factor—the cost of production. To date, the pressure has been very high on the control operation, size, and weight. As a result, the designs are complex and may not always incorporate design features that make for ease of production. As we look forward, we are anticipating the possibility of making some real progress in improving the producibility of these controls with some real savings in this factor of control costs.

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New Materials for Small Gas Turbines

Based on paper by

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Office of Naval Research, Navy Department

THE future of the small gas turbine depends on new materials being developed to meet the constant challenge of higher pressures and temperatures. New materials are being developed. Let's take a look at some of these materials in terms of their temperature resistance and potential applications in gas turbines.

Compressor Materials—Moderate Temperature Use (300-1000 F)

In general, the requirements for compressor blades are high resistance to corrosion, erosion, and abrasion and satisfactory creep and fatigue resistance. The most important design criterion has been creep resistance and the most frequent cause of service failures is fatigue. As compression ratios and compressor temperatures have increased, aluminum alloys, with a temperature limitation of about 350 F as a useful structural material, can no longer be utilized. The hardenable straight chromium stainless steels (approximately 12% Cr) are commonly used for compressor blades and low alloy steels for compressor discs.

Titanium Alloys

The most publicized impact in the field of new compressor materials has been made by titanium and its alloys. In fact, the virtues of titanium almost make it appear as a "natural" for compressor blades and wheels.

Titanium alloys offer great promise for filling the need for materials in the range of 300 to 800 F and possibly to 1000 F. Their light weight, excellent corrosion resistance to certain environments, outstanding strength to weight ratios, and fatigue-strength to tensile-strength ratio, as well as the availability of titanium ores make titanium alloys materials of significant potentialities and applicability.

Significant improvements have been

made in the melting and fabrication of titanium alloys, such that both sheet and forging alloys for use up to 750 F are available. The major problems associated with unalloyed titanium have been overcome, and the former difficulties associated with nonhomogeneity and cracking of titanium alloys have been largely cleared up.

In considering the applicability of titanium, the use of powder metallurgy techniques should not be disregarded, since they afford a means whereby titanium can be made competitive with many of the highly alloyed materials.

Thermenol

Thermenol is an iron base alloy containing primarily 16% aluminum and 4% molybdenum. Because of its outstanding oxidation resistance and its nonstrategic composition it has attracted serious consideration as a compressor blade and sheet material. The alloy is weldable and hot formable and exhibits satisfactory corrosion resistance in salt spray tests. In its preliminary state of alloy development it exhibits high temperature properties comparable to stainless steel. It appears to be useful as a structural material as high as 1000 F. Preliminary tests of Thermenol compressor blades have been most encouraging.

Sintered Aluminum Powder

An interesting Swiss development of a strong, high-temperature aluminum alloy called SAP (sintered aluminum powder) recently has attracted much attention. This new sintered aluminum product shows potentialities for use at temperatures of 800 F, which represents a major temperature increase over the best commercial high-temperature aluminum alloy. SAP is produced from fine aluminum powder by a combination of cold pressing, hot pressing, and extrusion practice. SAP rods can be further cold-or-hot-worked into sheets, shapes, or drop forgings.

In composition, SAP is equivalent to commercial 2S aluminum but it contains between 10% and 20% by weight of aluminum oxide. Typical room temperature mechanical properties are as follows:

Tensile strength	50,000 psi
Yield strength (0.2% offset)	32,000–36,000 psi
Elongation	8–10%
Reduction in area	10–12.7%

The strength and ductility properties can be varied by changing the amount, size, and distribution of the oxide phase.

Exposure to temperatures as high as 900 F for as long as 100 hr results in little or no change in the room temperature tensile properties. This is believed to be due to the effect of the finely dispersed oxide phase inhibiting grain growth and recrystallization. In general, the strength and creep resistance of SAP at 600 F are as much as two to five times greater than those of conventional aluminum alloys. In addition the fatigue properties of SAP are generally superior to those of aluminum alloys at temperatures greater than 400 to 500 F.

Its high-temperature strength properties have led naturally to consideration for possible use as a compressor blade material.

In addition to the potential importance of SAP as a structural material in its own right, SAP has provided a stimulus for the application of its basic principles to the development of other alloys. Work is underway with such metals as copper, nickel, cobalt, titanium, molybdenum, and magnesium and it is not improbable that a whole new series of sintered metal products may emerge from current research and development efforts. If these efforts are successful, we may anticipate a decided improvement in the high-temperature-strength properties of relatively pure metals and considerable saving in alloying elements.

Precipitation Hardened Stainless Steels

Another ferrous alloy development which is receiving attention these days is the use of precipitation-hardened stainless steels. Using less nickel than 18–8 and readily hardened by the precipitation of intermetallic compounds during heat-treatment, these steels have attractive strength to weight ratios at room temperature. At temperatures to 700 F the ratio is comparable to the best of the light alloys.

These steels can be formed by cold working or hot working in the soft condition and then treated in the temperature range of 850 to 1400 F to develop strength characteristics equivalent to many carbon and low-alloy steels. The high-temperature properties are good up to 800 F and in fact are superior to 18–8 stainless, low-alloy steels, titanium alloys, aluminum alloys, and magnesium alloys.

These new stainless alloys are available in sheet, strip, bars, wires, and forging billets; and some varieties are good casting alloys. Their corrosion resistance is generally superior to standard heat-treatable stainless steels and under some conditions equivalent to 18–8. Their high elastic limit and endurance strength and good high-temperature properties make the precipitation-hardened stainless steels attractive materials for missile and aircraft manufacture. They are being considered for compressor blading, aircraft landing-gear parts, valves, and other applications where resistance to oxidation and high stresses are required. They also appear to be promising spring materials.

Plastics

Within the temperature limit of approximately 550 F, reinforced plastics must also be considered as potential structural materials. Their high strength to weight ratio and their high damping capacity make them interesting compressor blade materials and, indeed, preliminary spin tests of plastic compressor blades have been quite favorable. A variety of resins are available and work is underway to develop higher modulus fibers. Metal coated glass fibers may be of interest along these lines.

Vanadium Alloys

Ductile vanadium has been developed in recent years and vanadium alloys should also receive consideration as a potential compressor material. The modulus to density ratio of vanadium is equal to that of steel and higher than for titanium. Vanadium has good corrosion resistance and good high temperature strength. Up to 1100 F the tensile strength of vanadium is superior to AISI 304 stainless steel, and between 1100 and 1800 F it has comparable strength. The poor resistance of vanadium to oxidation, however, would require the use of protective coatings.

Turbine Materials—High Temperature Alloys (1500-1800 F)

A major share of our high-temperature materials research and development effort is directed at the turbine stage of jet engines, since this is where potential gains in military performance can be achieved. Present turbine wheels operate up to about 1650 F. The immediate goal is to raise the temperature to 1800 F; the ultimate objective is to go as high as possible.

The turbine blades are subjected to the most punishing conditions of stress, temperature, and environment of all the turbine components. Although creep rupture strength is still the main design criterion, fatigue strength and thermal shock resistance are becoming increasingly important in advanced design engines.

Nickel Base Alloys

Recent improvements in nickel base alloys has permitted an increase in turbine inlet temperature to 1650 F with possibilities of going to 1700–1750 F in a reasonable time period. These alloys derive their high temperature strength properties from age-hardening reactions involving aluminum and titanium.

The use of vacuum-melting tech-

niques has enabled, in large part, the development of these superior nickel base alloys and the claim has been made that, in the future, the bulk of such alloys will be vacuum melted. It has been claimed that vacuum melting results in better forgeability and greater recovery of sound material; superior fatigue limit to tensile strength ratio; greater ductility; greater high temperature strength properties; greater resistance to intergranular penetration; and better over-all combination of properties.

Cobalt Base Alloys

Similar developments in cobalt base alloys are in progress, and it is anticipated that improved alloys will be available for 1600–1700 F turbine operation.

Cermets

Much attention has been focussed on metal-bonded carbides, borides, oxides, nitrides, and such, popularly called cermets. The development of cermets was centered around the attempt to take advantage of the high temperature strength of the ceramic or refractory compound phase and the ductility and thermal shock resistance of the binder.

As of this time, the most highly developed cermets are the cemented titanium carbide grades. Nickel base alloys are the most prevalent binder materials. Earlier grades had metal binder contents ranging from 20 to 30%, but because of low ductility and impact resistance present grades are running from 50 to 70% binder content. These metal-bonded titanium carbides exhibit strength properties up to 1800 F and oxidation resistance and thermal shock characteristics which make them potentially useful turbine blade and nozzle guide vane materials.

Titanium-carbide cermet turbine blades have satisfactorily passed 100 hr hot spin tests and the carbide cermets have also exhibited excellent results in nozzle guide vane tests.

The major problems confronting users of carbides and other cermets for turbine blades or guide vanes are low ductility, high notch sensitivity, and low impact resistance. Low ductility, in part, has been circumvented by modification of the current fir-tree root design of turbine blades. New design concepts have been developed by the NACA which avoid the stress concentrations at the fir-tree serrations and which compensate for the lack of ductility in the cermet by the use of ductile shims or retaining pins. These features have provided better load distribution, and root failures in spin tests have disappeared.

The low impact resistance is the most serious limiting factor in the application of cermets for turbine buckets or guide vanes. The high degree of foreign object damage in aircraft gas turbines requires that blade and vane materials have adequate impact resistance. This problem is sufficiently severe so as to cause serious doubt in many quarters about the practical use of cermets in large turbines. However, continuous improvement is being made in increasing the ductility and impact resistance, and recent encouraging results indicate that the properties of cast superalloys are being approached by the cermets.

The cermets, however, should be promising materials for small gas turbine applications. Integral disc and blade titanium carbide turbine wheels have been successfully spin tested by at least two carbide producers. We have spin tested slotted disc titanium carbide wheels based upon the Boeing 502 turbine design. These wheels were tested at 1600 F and performed most creditably.

A test rig has been constructed at the Naval Air Material Center to continue such tests up to 2000 F. If the simulated wheels perform satisfactorily, actual airfoil wheels will be tested.

Chromium Base Alloys

Chromium base alloys have been developed which exhibit good high temperature properties up to 1800 F. But such alloys suffer from the same disadvantage as cermets; namely, low ductility. However, recent work on the preparation of ductile chromium and more ductile chromium base alloys hold out some real hope for interesting developments in this field.

Super High Temperature Materials (1800 F-?)

Chromium Boride Cermets

A new group of chromium boride cermets has recently been developed, which based on their strength, thermal shock, and oxidation resistance at high temperatures, show significant promise for use up to 2100 F or higher temperatures. At 1800 F, the chromium boride cermets are twice as strong as the titanium carbide grades; or at the same strength level they exhibit a 200 F superiority. This is still an early development and an evaluation of gas turbine components will be initiated shortly.

Molybdenum Alloys

The outstanding high-temperature properties of molybdenum and its alloys have attracted considerable attention for the potential utilization of these materials for gas turbine applications and has led to intensive alloy development programs. In the temperature range of 1600 to 2000 F pure molybdenum exhibits better rupture strength than the best cobalt, nickel, or chromium-cobalt-nickel-iron base alloys, while the molybdenum base alloys which have been developed have strength properties at 2000 F superior to the commercial gas turbine blade materials at 1600 F. These properties are unequalled by any other material tested to date.

Unfortunately, a major obstacle limits the widespread use of molybdenum alloys for turbine applications. Molybdenum and its alloys undergo rapid oxidation, and satisfactory protective coatings are urgently needed. Much effort is proceeding along these lines, and coatings of nickel-chromium combinations appear promising for use up to 2000 F.

Columbium (Niobium) Alloys

Recent announcements of increased availability of columbium ores have led to increased attention to columbium alloys as high temperature structural materials. Like molybdenum, columbium exhibits outstanding strength properties at 1800 F. Alloy development programs are now underway. Columbium, most likely, will need to be protected against oxidation, but unlike molybdenum it does not have a volatile oxide.

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Future Industrial and Commercial Uses for the Small Gas Turbine

Based on paper by

Prof. P. F. Martinuzzi

Stevens Institute of Technology

PROBABLE future commercial and industrial applications for the small gas turbine include:

- Emergency electric generators.
- Drives for forced-draft fans and other steam boiler auxiliaries.
- Automobiles, trucks, and locomotives.

In the near future, when small gas turbine production lines are established and several makes and models are readily available, the emergency gas turbine electric generator, in powers from 30 kw to 600 kw, will constitute a very rich market capable of absorbing a considerable number of machines. If the initial cost is comparable, the gas turbine generator is much superior to the diesel generator now universally employed. Its cold starting ability suits it well to this application. Although specific

fuel consumption is high it is relatively unimportant since average running time per year is very low.

Several firms are studying the use of small gas turbines to drive forced-draft fans or other auxiliaries for steam boilers. Here, the turbine exhausts into the boiler furnace so that the high amount of heat contained in the exhaust is integrally recovered for boiler air preheating. In applications of this sort, although the efficiency of the gas turbine alone is low, the fuel is utilized extremely well. The easy starting of the gas turbine and its hot exhaust considerably accelerate the starting of the steam boiler.

One of the most interesting fields of application for small gas turbines is that of automotive and railway traction. Rover and Austin in Britain, Socema in France, and Fiat in Italy have built experimental gas turbine cars. Laffly and Socema have built gas turbine trucks. And, a light locomotive powered by two Boeing gas turbines has been built for the U.S. Army. All these machines use simple split-shaft gas turbines without heat exchangers.

It is well known that the three largest U.S. automotive manufacturers are extremely interested in gas turbines for automotive use. General Motors has shown a gas turbine experimental car and bus; Ford and Plymouth have publicly announced that they have experimental automotive gas turbines with heat exchangers and that these have already been fitted to test cars.

In examining the advantages and disadvantages of automotive gas turbines, a clear distinction must be made between their use in heavy trucks or buses and in passenger cars. In trucks, the main advantage lies in weight saving. This can be considerable, of the order of 2 tons, and is due only in part to the lighter weight of the gas turbine and mainly to the fact that the very heavy and complicated truck transmission, which requires eight or ten speeds, can be replaced by a very light gearbox with many fewer speeds. The excellent torque characteristics of the gas turbine and the very high speed and low torque of the power shaft permit this considerable saving.

The situation in the passenger car field is quite different. The saving in weight is much smaller and not vitally important. The main attraction of the gas turbine for the car user lies in the incredibly smooth power and acceleration, much better than any gasoline engine or any automatic transmission can give. The author, for many years a racing car designer and driver, has ridden in two different gas turbine cars and can testify that the feel of the gas turbine car is beyond anything a conventional car can offer, whatever its power or cost.

Against this advantage, there are several defects: high fuel consumption, noise, the large quantity of exhaust gas, the fact that engine braking is at present not possible, the fact that, although acceleration is spectacular, there is a slight delay in power response when the throttle is suddenly opened and, finally, the feeling the user has that the engine consists mainly of a red hot metal disk turning at incredible speeds and very highly stressed, so that things might not be quite pleasant should it fly apart.

Most of these defects can be cured. Noise can quite easily be muffled, particularly as regards the car passenger. The exhaust, although much bulkier than that of a piston engine car, is much purer; it contains no lead or lubricating oil fumes, nearly all fuel is completely burnt to carbon dioxide and water vapor, and a large quantity of oxygen is still present. With only slight complications, very effective engine braking can be obtained and the response delay can be avoided, while the danger of turbine disc explosions can be prevented by proper shielding. The fundamental disadvantage consists in the very high fuel consumption, so that gas turbine cars without heat exchanger seem limited to special models, such as sports cars, in very small production.

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Small Turbines for Aircraft in the Future

Based on paper by

A. T. Gregory
Fairchild Engine and Airplane Corp.

PROBABLE future applications of the small turbojet include:

- Missiles
- Jet fighters and trainers
- Personnel aircraft and small transports
- VTOL aircraft

New high performance aircraft and missiles should be possible in the future utilizing small turbojets. These aircraft and missiles should be capable of flying at Mach numbers of 2 and above and up to very high altitudes. A small turbojet is particularly suited for supersonic and high altitude flight by virtue of its extremely light weight, its low frontal area, and moderate pressure ratio. It is expected, therefore, that many future aircraft and missiles required to fly under these conditions will utilize small turbojet engines.

A small, high performance jet fighter would be made possible by the use of small turbojets. Such a fighter requires a small engine with a high thrust to weight ratio and a high thrust to frontal area ratio.

A second type of aircraft for which the small turbojet is particularly suited is the jet trainer. Future engines will be capable of powering trainer aircraft at supersonic speeds by virtue of their high thrust to weight and thrust to frontal area ratios.

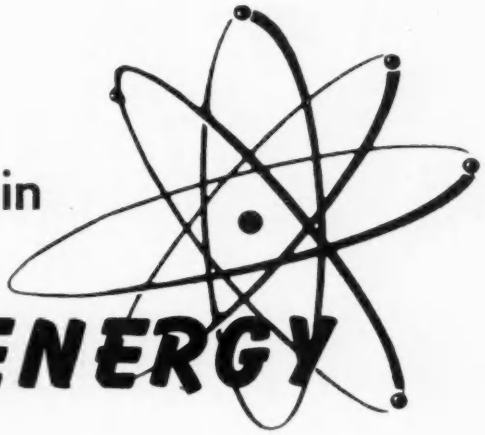
Small turbojets will probably find wide usage in personnel aircraft and small transports. Thrust requirements for these aircraft are such that in most cases two or four of the new engines could provide adequate thrust. We should expect therefore, that future personnel aircraft and small transports will be capable of flying in the high subsonic speed regime. Speeds of around 500 mph should become common for such aircraft in another five to ten years.

The vertical take-off and lift aircraft is an application in which the small turbojet has an outstanding advantage. Here, the high thrust to weight ratio of these engines is of the greatest importance. Heavier loads can be carried than when using engines of lower thrust to weight ratio. Several small engines would be needed to provide the total necessary lift. Greater safety can be provided by such an installation, since a failure of one engine would result in the loss of a relatively small percentage of the total thrust compared to installations of two or three large engines.

The use of a number of small turbojets in the place of one large engine has additional advantages for other types of aircraft which should not be overlooked. First of all, when cruising with a number of small turbojet engines, maximum economy is obtained by shutting off one or more engines and operating the remaining ones near their design point. In this way, the operating engines are maintained at close to optimum efficiency. As a result, good specific fuel consumption can be obtained over a wide range of overall total thrust values and airplane Mach numbers. This method of operation obviates the rather serious problem of off-design-point performance which would be encountered by a single large engine. Improved fuel economy and greater airplane range might be expected to result.

Small turbojets can also be expected to take other forms than the simple jet engine. One possibility is a turboprop version of the turbojet. The turbojet in this case would function as the gas generator supplying gas for the power turbine drive. A family of light weight turboprops could be built around one, two, or more of the gas generator units, thereby providing a wide range of available powerplants.

Selected Readings in ATOMIC ENERGY



Suggested by

SAE Nuclear Energy Advisory Committee

THE field of Atomic Energy has grown at a prodigious rate with a parallel outpouring of published material. To present even a fraction of this would require thousands of references. That's why the SAE Nuclear Energy Advisory Committee has prepared the following bibliography as a service to SAE members. It includes comprehensive books, articles, reviews, and periodicals covering all of the major phases of development in the area.

The sixteen-volume collection of papers presented at the 1955 Conference on the Peaceful Uses of Atomic Energy held at Geneva, Switzerland, is by far the most extensive compilation of technical articles on the subject. The various volumes are listed under the appropriate categories. Another series of a similar nature is the National Nuclear Energy Series, which presents treatises based on research carried out for the most part under the Manhattan Project. Some of these are listed under the appropriate headings.

The proceedings of the first international congress on peacetime uses of atomic energy, sponsored by the American Institute of Chemical Engineers and the University of Michigan, and held at Ann Arbor in 1954, included papers on a broad range of subjects. These were published in three volumes, designated as A.I.Ch.E. Chemical Engineering Progress Symposium Series Nos. 11, 12, and 13, Vol. 50. They are listed in the miscellaneous category.

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Nuclear Engineering

Nuclear Science Abstracts

Nucleonics

Radiation Research

Radiators . . .

. . . are tailored for operating conditions. Good design practice requires correct interpretation and analysis of all factors and final judicious compromise.

Based on paper by **H. A. Reynolds,** Harrison Radiator Division, General Motors Corp.

THREE major factors must be considered when designing a radiator for a car or truck:

1. Thermal capacity required to cool the engine.
2. Structural strength needed to withstand a reasonable amount of stress, vibration, and shock without permanent failure.
3. Compatibility with acceptable quality and manufacturing cost.

Once performance requirements and installation specifications have been analyzed, a preliminary selection of the type of core surface must be made which will be best adapted to the specific installation. There are two basic types of cores—the cellular and the tubular, and the latter is made in two designs, tube-and-flat-fin type, and tube-and-corrugated-fin type.

The cellular type is easily adapted to high volume production and is therefore cheaper to manufacture than the tubular. The almost perfect bond between the water tube and the air cell surface, plus the turbulence created in the cooling air stream by the design of the air centers, result in a thermal efficiency per pound of core metal superior to that of the tubular type. Cellular cores are also quite flexible so that considerable road shock and vibration are absorbed with out excessive fracture. Field repairs and core replacement are accomplished more easily and cheaply as compared with tubular cores on which the header sheets are not readily detachable. The flexibility, however, makes the cellular core susceptible to deflection and eventual failure when subjected to severe intermittent pressures.

The tube-and-flat-fin type of tubular cores is specified for heavy-duty truck service where a rugged core element is desired. It is seldom specified unless the engine cooling system pressure exceeds 7 psi, or the type of service requires great structural strength. The tube-and-corrugated-fin type core combines the ruggedness and resistance to internal cooling system pressures found in the tube-and-flat-fin type, with the superior thermal efficiency of cellular cores by using cellular air centers.

After selecting the core surface, the required core surface area must be calculated. The factors influencing this are:

1. Total heat to be dissipated.
2. Ambient or core inlet air temperature.
3. Available air volume.
4. Rate of engine coolant circulation.
5. Engine coolant.
6. Maximum permissible engine coolant temperature.
7. Maximum system operating pressure.
8. Core dissipation capacity at specified air and liquid flows, and temperature differential.

Next, it is necessary to determine whether the available space limitations are sufficient to accommodate the required core surface area. If the space is inadequate, requirements are recalculated with alternate core surfaces to select one which can be used. After that, the preliminary overall design is completed.

A radiator is then built to this design and tested for performance and for a check on installation design. The installation and test results are then analyzed and the design revised as required to meet specifications.

The need for consideration of compromises is usually established early in the calculating stage of the program. However, various factors not apparent in preliminary design stages will come to light during the test period, and these must be compensated for to maintain specifications. (Paper "Radiator Cooling Development" was presented at SAE Buffalo Section Meeting, Jan. 25, 1956. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N.Y. Price: 35¢ to members, 60¢ to nonmembers.)

Detergent Oils May Accelerate Engine Wear

HARMFUL—not just harmless—particles are being carried through automobile engines by detergent oils. The greater the ability of detergent oil to keep agglomerations of contaminant particles small and suspended in the oil, the less abrasive contaminant a given filter can remove—and the greater the wear.

Also, the coarser the filter's rating, the greater the wear.

If the concentration of the detergent is strong enough to disperse abrasive contaminant particles in the oil and to prevent their adsorption to the oil filter media or to other contaminants already trapped by the filter, then the particles will be carried through the filter.

Since many of the particles of contaminant that enter the oil originate in the combustion zone and are blown by the rings down into the crankcase, they are very small when they first enter the oil. The detergent is designed to be most effective with these contaminants; and the ability of a given filter to remove them from the oil is inversely proportional to the dispersive ability of the additive.

Most of these particles are relatively low in hardness and wearing properties; however, if abrasive particles are also peptized by the detergent and

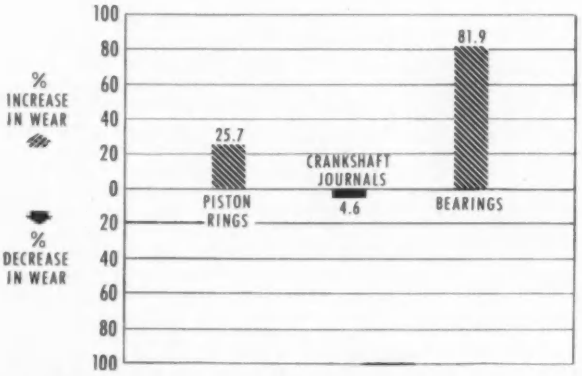


Fig. 1—Effect on engine wear of abrasive dust particles not removed by filter when additive oil was used. The base line (zero line) is the average wear with base oil. (Filters were used in both tests.)

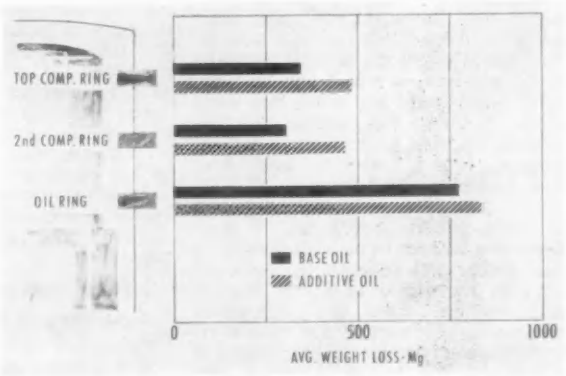


Fig. 2—Piston ring wear from abrasive particles not removed by the filter is greater for the additive oil for all three rings.

—That is, if the detergents keep abrasive contaminant particles so well suspended that they can pass through filters.

R. J. Pocock, Ford Motor Co.

Based on paper "Wear—Where and When" presented at SAE Annual Meeting, Detroit, January, 1956.

carried in the oil, the engine wear will increase.

Fig. 1 shows the effect of an additive oil on engine wear resulting from the suspension of abrasive contaminants in the oil. (The abrasive added was Standardized Air Cleaner Test Dust (fine), but abrasives derived from combustion or ingested with air into the engine would give the same effects.)

The wear of the piston rings by these abrasive particles is shown in Fig. 2. Note that when a base oil is used the filtering is more efficient and there is less wear.

Fig. 3 shows the effect of these suspended abrasive particles on the bearings. Here, again, the base oil is more efficiently filtered.

The finer the particle a filter can remove, the less the engine wear. Fig. 4 shows the cylinder bore wear which results when abrasive dust particles pass through filters of different micron ratings. The wear that occurs with the various filters is given as a percentage of the wear with the same abrasive dust put into the oil but with no filter in the system. The "zero micron filter" represents a 100% efficient filter system. This condition was simulated by using clean oil with no abrasive dust added.

Fig. 5 shows the relative magnitude of piston

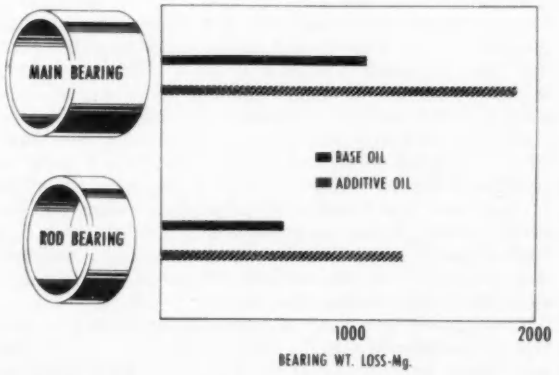


Fig. 3—Bearing wear from abrasive particles is greater for both the main and rod bearings when the additive oil is used.

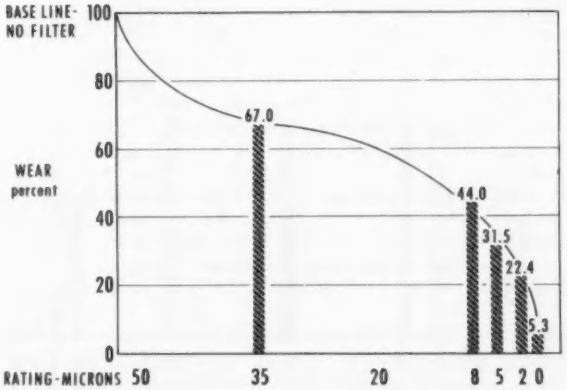


Fig. 4—Cylinder bore wear for various filters. The finer the filter the less the wear.

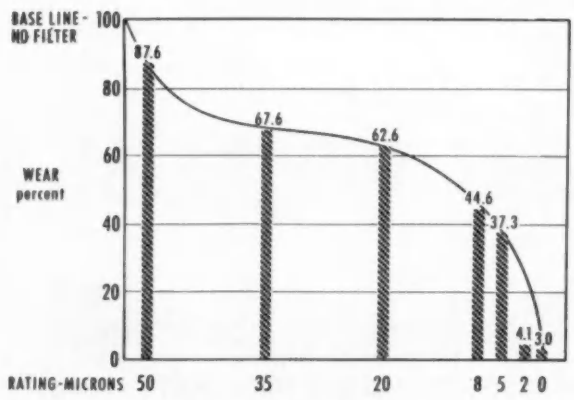


Fig. 5—The effect of abrasive dust particle size passed by the filter on piston ring wear. Here, too, the finer the filter the less the wear.

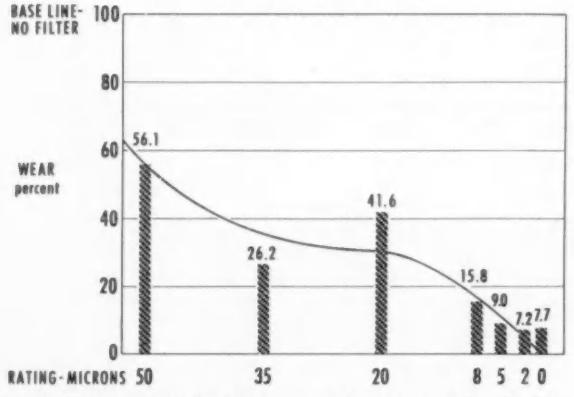


Fig. 6—The effect of abrasive dust particle size passed by the filter on crankshaft journal wear. Note that wear with the 20 micron filter was greater than that with a 35 micron filter. This is an example of the different wear rates and wear patterns found among different parts of the engine.

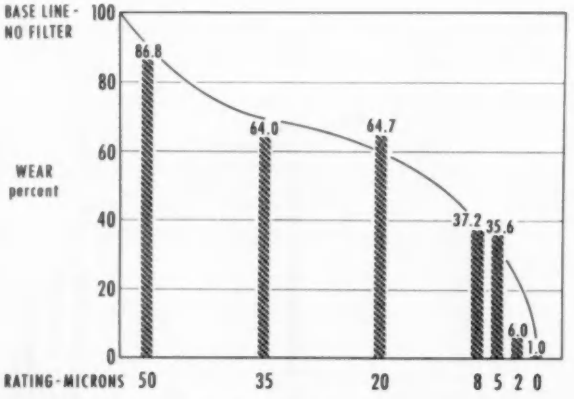


Fig. 7—Effect of abrasive particle size passed by the filter on bearing wear. Note that any filter which lets particles 5 microns or larger through results in appreciable wear.

ring weight loss for each of the filters. These results suggest that piston ring wear is considerable even with particles no larger than 5 microns.

Fig. 6 shows the wear of the crankshaft journals. The total wear of main journals and connecting rod journals is represented.

In Fig. 7 the combined wear of the bearing is illustrated. In the comparing wear relative to particle size removal efficiency of the filters, there is a significant change in the level of wear when particles of 5 microns or larger are removed from the oil by the filter. The pattern of wear versus particle size was remarkably consistant for each of the wear criteria used.

This tends to contradict the theory that the nominal clearances of parts in an engine are related to the size of particles causing wear. On the other hand, it may be that the actual clearances between the piston ring and cylinder bore and between the crankshaft journals and bearings are identical, probably as close as a film of oil much less than one micron in thickness.

(For complete paper on which this abridgment is based, write SAE Special Publications Department, 485 Lexington Ave., New York 17, N.Y. Price: 35¢ to members; 60¢ to nonmembers.)

Discussion

M. M. Roensch

Director, Chevrolet Engineering Laboratory, General Motors Corp.

I would like to supplement Pocock's data with some recent information on the importance of keeping clean air going into the engine. In the field, we repeatedly come in contact with excessively worn engines and on careful analysis find that in some way, due to faulty installation or poor maintenance, small leaks have occurred where dirt can be drawn into the induction system of the engine without first going through the air cleaner.

Recently, we had the occasion to run some controlled tests under severe dust conditions which emphasize once again the importance of preventing any air by-passing the oil bath air cleaner. During this test a V-8 passenger car engine was operated for 7212 miles at 30–40 mph under severe dust conditions during which all the air for one bank of the engine was taken through the oil bath air cleaner. Most of the air for the other bank of the engine was also taken through this same cleaner, but a small hole, only 0.110 in. in diameter, was drilled in the carburetor body through which a small amount of the dusty air could be drawn in directly from under the hood.

Comparing the wear of the worst cylinder in each bank, the increase in top ring gap and the cylinder bore wear at the center of top ring travel were approximately twice as much for the bank which received the small amount of dusty air.

From these data it is easy to understand why it is important, for maximum life, that the engine be

not only equipped with an efficient air cleaner, but also that care be taken that no air leaks, no matter how small, be permitted to occur anywhere between the air cleaner and the cylinder.

H. R. Jackson

Supervising Automotive Engineer, Atlantic Refining Co.

In laboratory tests, Pocock found that filtered detergent oil permits considerably more abrasives wear throughout the engine than the filtered based oil. In our laboratory work using SOFTC–1 (Standard Oil Filter Test Contaminant–1) as the oil contaminant we have found no harm resulting from detergent oils. This indicates that either there are major differences in commercial detergents, or that test techniques are all important. We believe that the latter statement is more to the point. Hence, service road test results are more reliable; and here, detergent oils fare quite well.

W. S. James

Engineering and Research Consultant

In discussing laboratory test results, concerning abrasive wear in engines, Pocock indicates that the wear of cylinder bores, piston rings, crankshafts, and bearings is reduced by using oil filters capable of removing smaller dirt particles.

A quick glance at Figs. 4–7 might lead one to believe that most of the wear was due to the larger particles. This is probably not the case. A filter which passes 50 micron particles will pass smaller particles and therefore the wear encountered with a 50 micron filter includes the wear due to all particles smaller than 50 microns.

The percent wear when 0–10 micron particles are passed by the filter includes the wear due to 0–5 micron particles. By subtracting the percent wear due to the 0–5 micron dirt from that due to the 0–10 micron dirt, an estimate of the wear due to the 5–10 micron particles can be obtained.

This procedure has been used to obtain figures which show the percent wear due to 0–5, 5–10, 10–20, and 20–40 micron size-range particles. These data show very clearly that in the case of the cylinder bores, the piston rings, and the bearings the wear due to the smaller particles (0–5 microns) is two to three times as great as that due to the larger particles.

This is not so in the case of the crankshaft, where the wear is almost independent of particle size. This is an example of the different wear rates and wear patterns found among different parts of the engine. Measuring the wear rate of any one part of an engine will not give much information on the wear rates of other parts.

There is also a general similarity between the weight percent distribution of the several size-ranges in the dust and the wear of bores, rings, and bearings. This indicates that the quantity of dust of a given size-range might account for the differences in wear with dusts of different size-ranges.

Wear increases as the quantity of dirt of a given size increases, although not in direct proportion.

Wear increases and then decreases as the particle size-range is increased, with some parts such as the rings and bores. In the case of rod and main bearings, however, the wear continues to increase as the size-range of the dust is increased. These differences in wear due to particle size-range might be explained by differences in clearances between the moving parts. When the clearance is very small, as in the case between the rings and the bore, large particles have difficulty getting between the rubbing surfaces.

Dust hardness is another factor which affects abrasive wear. The harder the dust the greater the wear of engine parts. A tremendous difference in wear is noted between soft dirts (4 and 6 on Moh's scale) and hard dirts (7 and 9 on Moh's scale).

Because of the effects of quantity and hardness of dirt on engine wear it may be difficult to isolate the effects of particle size-range in Pocock's Figs. 4–7. These figures do show very clearly, however, that in the presence of abrasive dirt the wear of engine parts decreases as the ability of an oil filter to remove small particles increases.

Here's How the Test Was Run

The curves and conclusions indicated in this article are based on laboratory tests performed by the author and his staff.

The tests were conducted on valve-in-head, 6 cyl, 215 cu in. Ford engines at 3800 rpm and three-quarter load for 20 hr. Engines were fitted with a conventional radiator for cooling, and SAE 30 oil meeting MIL-O-2104A specification was used in the crankcase.

Standard Air Cleaner Test Dust (fine) was added to the crankcase oil at the rate of one gram per hour. This abrasive dust was prepared in a slurry of crankcase oil by mixing measured quantities of dust and oil together, enough for 5 hr of operation. Additions of slurry were made after each 30 min of engine operation, at which time an equivalent volume of crankcase oil was withdrawn and saved. This oil was then blended with the measured quantity of abrasive dust to prepare the mix for the following 5-hr period. Additions of slurry were made through a special tube insert in the oil pan leading directly to the vicinity of the oil pickup tube.

In the clean oil test, representing a 100% efficient filter system, abrasive dust was not added, and the oil was changed after each 5 hr of operation. In addition, the engine was equipped with one of the most effective oil filters in order to minimize wear resulting from engine-made contaminants during the 5-hr periods.

The base oil used in the test was an SAE 30 grade of MIL-L-15016 specification.

SAE Sealed Beam Standards Are Revised and Expanded to Cover

New 4-Lamp Dual Sealed-Beam Roadlighting System

Howard Mead, Chairman, Lamp Subcommittee,
Val J. Roper, Chairman, Bulb Subcommittee
of the **SAE Lighting Committee**

PERFORMANCE and dimensional requirements for the new four-lamp headlighting system, which makes its debut on some 1957 cars, have been established by revision in SAE Sealed Beam Standards. The revisions expand the standards to cover this development.

Improved Lower Beam

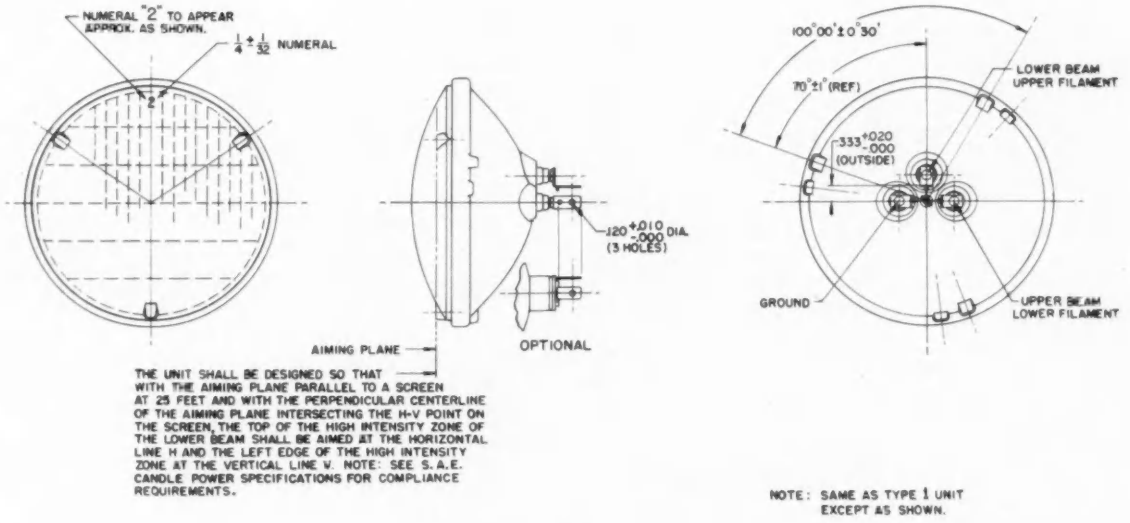
Chief feature of the new system is the improved lower beam, made possible by a separate pair of units designed specifically for the lower beam.

It has long been recognized that best optical control is obtained by the use of a filament placed at the focal point of the parabolic reflector. The filaments supplying the lower beam are at the focal point of their respective reflector. And the lenses are designed particularly for the lower beam without compromise. Each of the units providing the lower beam, known as Type 2, also has another filament which provides *part* of the upper beam. But the lens is designed to give optimum results with the lower beam. Hence the upper beam portion supplied by the second filament in the Type 2 lamps is not by itself suitable as an upper or driving beam.

The balance of the upper beam—the more important portion which furnishes illumination for distant seeing—is provided by another single-filament unit, which also has its filament at the focal point of the reflector.

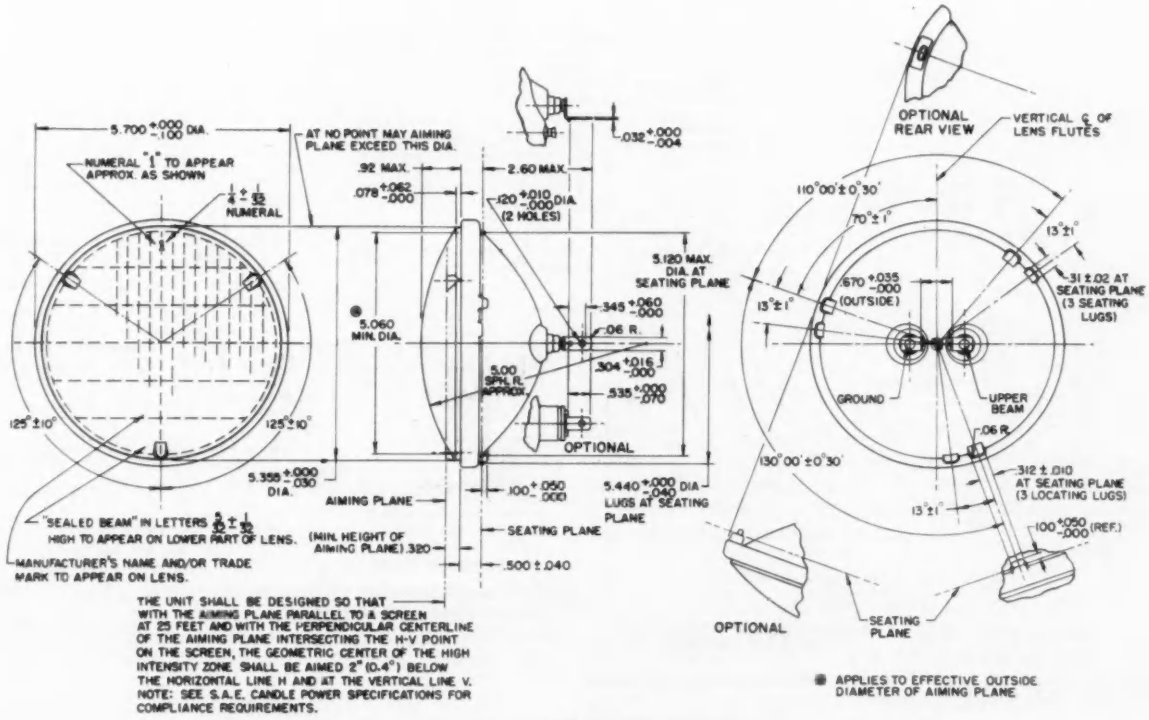
Thus the upper and lower beams are provided by a pair of units at each side of the car. This pair of units of 5¾-in. diameter functions the same as the single 7-in. sealed beam unit, insofar as switching is concerned.

It has often been pointed out that it would be very nice if *both* filaments could be placed at the focal point. In effect, this four-lamp system using dual sealed beam units has "both filaments at the focal point." The entire lower beam is provided by a filament at the focal point, and the important


NUMERAL "2" TO APPEAR APPROX. AS SHOWN.
1/4 ± 1/32 NUMERAL
.120 +.010 -.000 DIA. (3 HOLES)
OPTIONAL
AIMING PLANE
THE UNIT SHALL BE DESIGNED SO THAT WITH THE AIMING PLANE PARALLEL TO A SCREEN AT 25 FEET AND WITH THE PERPENDICULAR CENTERLINE OF THE AIMING PLANE INTERSECTING THE H-V POINT ON THE SCREEN, THE TOP OF THE HIGH INTENSITY ZONE OF THE LOWER BEAM SHALL BE AIMED AT THE HORIZONTAL LINE H AND THE LEFT EDGE OF THE HIGH INTENSITY ZONE AT THE VERTICAL LINE V. NOTE: SEE S.A.E. CANDLE POWER SPECIFICATIONS FOR COMPLIANCE REQUIREMENTS.
100°00'±0°30'
70°±1° (REF)
LOWER BEAM UPPER FILAMENT
.333 +.020 -.000 (OUTSIDE)
GROUND
UPPER BEAM LOWER FILAMENT
NOTE: SAME AS TYPE 1 UNIT EXCEPT AS SHOWN.

TYPE 2

Fig. 1—SAE Dimensional Specifications for TYPE 2 Dual Sealed Beam Units


5.700 +.000 -.100 DIA.
NUMERAL "1" TO APPEAR APPROX. AS SHOWN
1/4 ± 1/32 NUMERAL
AT NO POINT MAY AIMING PLANE EXCEED THIS DIA.
.92 MAX.
.078 +.062 -.000
2.60 MAX.
.032 +.000 -.004
.120 +.010 -.000 DIA. (2 HOLES)
5.120 MAX. DIA. AT SEATING PLANE
5.060 MIN. DIA.
.345 +.060 -.000
.06 R.
.304 +.016 -.000
5.00 SPH. R. APPROX.
.535 +.000 -.070
OPTIONAL
125°±10°
125°±10°
5.355 +.000 -.030 DIA.
AIMING PLANE
.100 +.050 -.000
5.440 +.000 -.040 DIA. LUGS AT SEATING PLANE
SEATING PLANE
(MIN. HEIGHT OF AIMING PLANE) .320
.500 ± .040
"SEALED BEAM" IN LETTERS 1/8 ± 1/32 HIGH TO APPEAR ON LOWER PART OF LENS.
MANUFACTURER'S NAME AND/OR TRADE MARK TO APPEAR ON LENS.
THE UNIT SHALL BE DESIGNED SO THAT WITH THE AIMING PLANE PARALLEL TO A SCREEN AT 25 FEET AND WITH THE PERPENDICULAR CENTERLINE OF THE AIMING PLANE INTERSECTING THE H-V POINT ON THE SCREEN, THE GEOMETRIC CENTER OF THE HIGH INTENSITY ZONE SHALL BE AIMED 2° (0.4°) BELOW THE HORIZONTAL LINE H AND AT THE VERTICAL LINE V. NOTE: SEE S.A.E. CANDLE POWER SPECIFICATIONS FOR COMPLIANCE REQUIREMENTS.
OPTIONAL REAR VIEW
VERTICAL ℄ OF LENS FLUTES
110°00'±0°30'
70°±1°
13°±1°
13°±1°
.670 +.035 -.000 (OUTSIDE)
.31 ±.02 AT SEATING PLANE (3 SEATING LUGS)
GROUND
UPPER BEAM
.06 R.
130°00'±0°30'
.312 ±.010 AT SEATING PLANE (3 LOCATING LUGS)
13°±1°
.100 +.050 -.000 (REF.)
OPTIONAL
SEATING PLANE
● APPLIES TO EFFECTIVE OUTSIDE DIAMETER OF AIMING PLANE.

TYPE 1

Fig. 2—SAE Dimensional Specifications for TYPE 1 Dual Sealed Beam Units

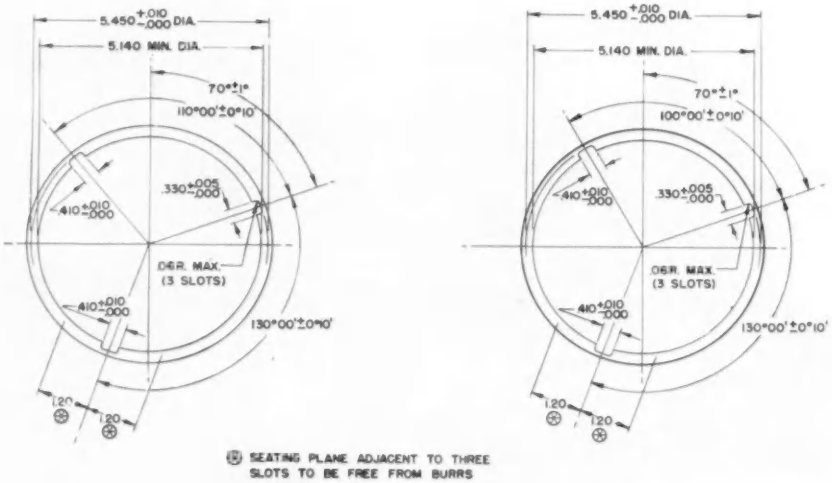


Fig. 3—SAE Mounting Ring Specifications for Housings Incorporating Dual Sealed Beam Units

FRONT VIEW OF SLOTS OR NOTCHES FOR $5\frac{3}{4}$" SEALED BEAM HEADLAMP MOUNTING RING OR LAMP BODY

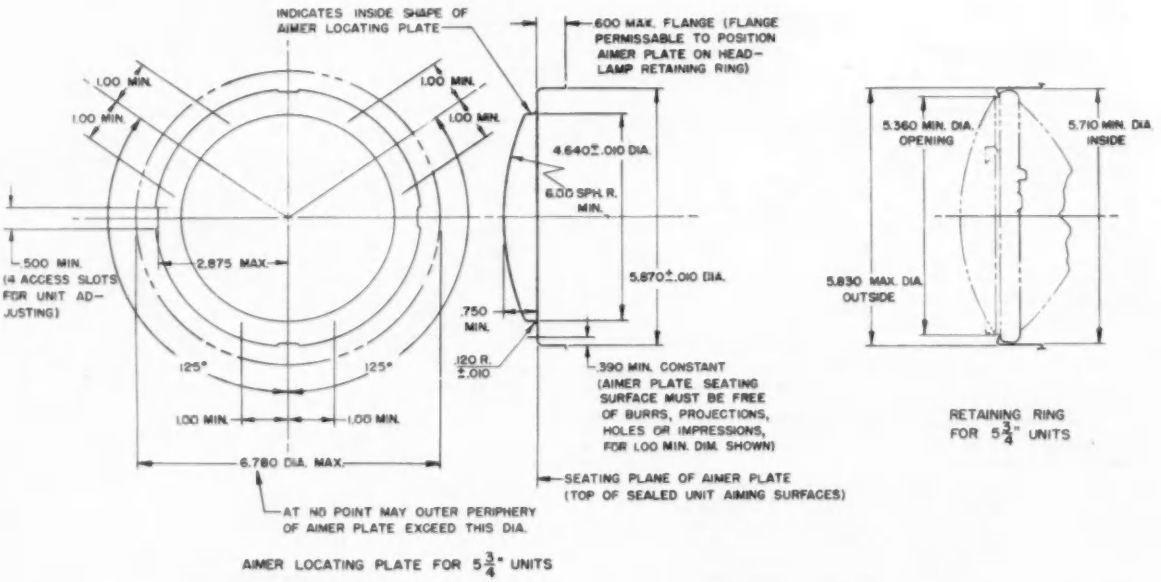

INDICATES INSIDE SHAPE OF AIMER LOCATING PLATE
.600 MAX. FLANGE (FLANGE PERMISSABLE TO POSITION AIMER PLATE ON HEAD-LAMP RETAINING RING)
1.00 MIN.
4.640±.010 DIA.
6.00 SPH. R. MIN.
.500 MIN. (4 ACCESS SLOTS FOR UNIT ADJUSTING)
2.875 MAX.
5.870±.010 DIA.
.750 MIN.
.120 R. ±.010
125°
.390 MIN. CONSTANT (AIMER PLATE SEATING SURFACE MUST BE FREE OF BURRS, PROJECTIONS, HOLES OR IMPRESSIONS, FOR 1.00 MIN. DIM. SHOWN)
6.780 DIA. MAX.
AT NO POINT MAY OUTER PERIPHERY OF AIMER PLATE EXCEED THIS DIA.
SEATING PLANE OF AIMER PLATE (TOP OF SEALED UNIT AIMING SURFACES)
AIMER LOCATING PLATE FOR $5\frac{3}{4}$" UNITS
5.360 MIN. DIA. OPENING
5.710 MIN. DIA. INSIDE
5.830 MAX. DIA. OUTSIDE
RETAINING RING FOR $5\frac{3}{4}$" UNITS

Fig. 4—SAE Aimer Plate Specifications for Housings Incorporating Dual Sealed Beam Units

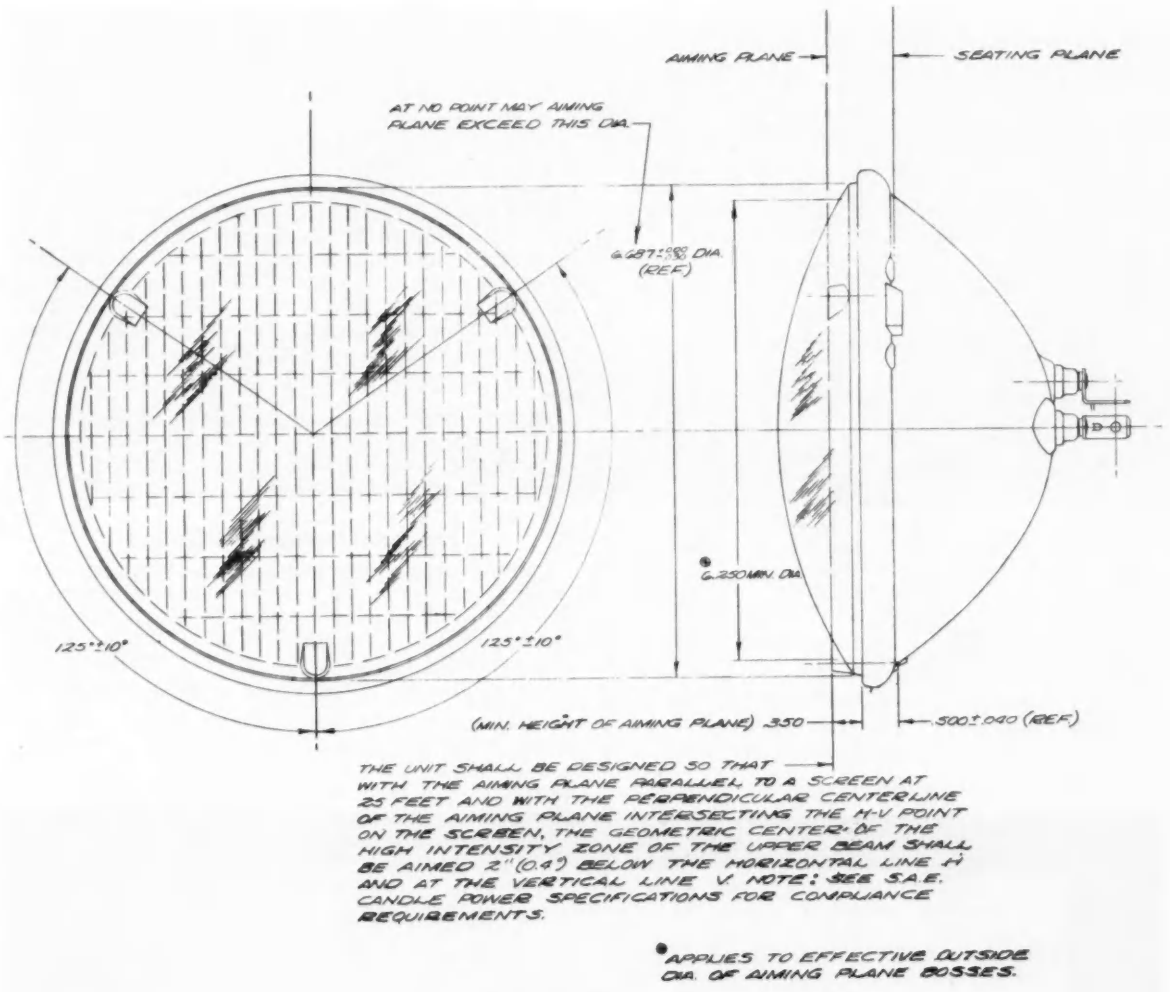

AIMING PLANE
SEATING PLANE
AT NO POINT MAY AIMING PLANE EXCEED THIS DIA.
Ø 287 DIA. (REF)
Ø 230 MIN. DIA.
125°±10°
125°±10°
(MIN. HEIGHT OF AIMING PLANE) 350
500±.040 (REF)
THE UNIT SHALL BE DESIGNED SO THAT WITH THE AIMING PLANE PARALLEL TO A SCREEN AT 25 FEET AND WITH THE PERPENDICULAR CENTERLINE OF THE AIMING PLANE INTERSECTING THE H-V POINT ON THE SCREEN, THE GEOMETRIC CENTER OF THE HIGH INTENSITY ZONE OF THE UPPER BEAM SHALL BE AIMED 2" (0.4°) BELOW THE HORIZONTAL LINE H AND AT THE VERTICAL LINE V. NOTE: SEE S.A.E. CANDLE POWER SPECIFICATIONS FOR COMPLIANCE REQUIREMENTS.
• APPLIES TO EFFECTIVE OUTSIDE DIA. OF AIMING PLANE BOSSES.

Fig. 5—Mechanically Aimable 7-in. Sealed Beam Unit

part of the upper beam in terms of distance seeing is also provided by a filament at the focal point.

Type 2 Unit

The Type 2 unit used in the system is shown in Fig. 1. Dimensions necessary to interchangeability have been established. The locating bosses on the rear of the reflector have been so established that the Type 1 and Type 2 units are not interchangeable.

The Type 2 unit (trade number 4002), which provides part of the lower beam and part of the upper beam, has a 50-watt lower beam filament at focus and a 37½-watt filament, not at focus, which provides part of the upper beam. This unit is identified on the front at the top of the lens with the number 2 molded in the glass. The manufacturer's identification is at the center, and the name "Sealed Beam" is at the bottom of the lens. The trade number 4002 is stamped on the back.

Type 1 Unit

The Type 1 unit (trade number 4001), shown in Fig. 2 has a single 37½-watt filament. Note the different arrangement of one of the locating bosses at the rear, to prevent interchange of the Type 1 and Type 2 units.

Fig. 3 shows the mounting ring specifications to insure that the 5¾-in. units made to meet their specifications will fit all headlamp housings. Retaining ring specifications also have been estab-

Sealed Beam Headlamp Units - SAE Standard — Page #4

TEST POINT VALUES FOR 7" SEALED BEAM UNITS

Upper Beam (One 7" Unit)			Lower Beam (One 7" Unit)		
Position	CP Max.	CP Min.	Position	CP Max.	CP Min.
1U-3R and 3L	-	500	1-1/2U-1R to right	1,000	-
2U-3R and 3L	-	1,000	1U-1L to left	500	-
1U-3R and 3L	-	2,000	1/2U-1R to 3R	2,000	-
1/2D-V	-	20,000	1/2U-1L to left	800	-
1/2D-3R and 3L	-	10,000	1/2D-1R to right	10,000	-
1/2D-6R and 6L	-	3,250	1/2D-1R,or 2R,or 3R	-	3,750
1/2D-9R and 9L	-	1,500	1/2D-1L to left	2,000	-
1/2D-12R and 12L	-	750	1D-1L to 6L	-	1,000
2D-V	-	5,000	1-1/2D-1R,or 2R,or 3R	-	10,000
2D-9R and 9L	-	1,500	1-1/2D-9R and 9L	-	750
3D-V	-	2,500	1D-1R and 15L	-	500
3D-12R and 12L	-	750	4D-4R	12,500	-
4D-V	5,000				
MAXIMUM	37,500				

TEST POINT VALUES FOR 5-3/4" FOUR-LAMP DUAL SEALED BEAM UNITS

Upper Beam (One Type 1 and One Type 2 Unit)			Lower Beam (One Type 2 Unit)		
Position	CP Max.	CP Min.	Position	CP Max.	CP Min.
1U-3R and 3L	-	750	1U-1L to L	500	-
2U-3R and 3L	-	1,500	1/2U-1L to L	800	-
1U-3R and 3L	-	5,000	1/2D-1L to L	2,000	-
1/2D-V	-	25,000	1-1/2U-1R to R	1,000	-
1/2D-3R and 3L	-	15,000	1/2D-1R to 3R	2,000	-
1/2D-6R and 6L	-	5,000	1/2D-2R	10,000	6,000
1/2D-9R and 9L	-	3,000	1D-6L	-	1,000
1/2D-12R and 12L	-	1,500	1-1/2D-2R	-	15,000
2D-V	-	5,000	1-1/2D-9L and 9R	-	1,000
2D-9R and 9L	-	2,000	2D-15L and 15R	-	700
3D-V	-	2,500	4D-4R	12,500	-
3D-12R and 12L	-	1,000			
4D-V	5,000	-			
MAXIMUM	37,500	-			

Fig. 6—SAE Photometric Limits for 7-in. and 5¾-in. Dual Sealed Beam Units

lished to insure complete interchangeability regardless of the manufacturer.

Aimer Locating Plate

Another important specification which had to be established is that for an aimer locating plate to seat on the three aiming bosses or pads on the face of the lens (Fig. 4). All units will have the aiming pads to facilitate easy and accurate mechanical aiming with the simple and relatively inexpensive mechanical aimers that will be available. Of course they also can be aimed visually or with the optical aimers now in use. In this connection, it should be mentioned that SAE Sealed Beam Dimensional Standards now include a drawing (Fig. 5) showing aiming bosses on 7-in. sealed beam units.

Fig. 6 tabulates the photometric limits at the various test points for the present improved sealed beam headlamps. It shows also the new SAE values for the four-lamp dual sealed beam units.

Test Point Positions and Values

The meaning of the test point positions and values is explained in Fig. 7 which shows a laboratory screen with horizontal and vertical lines 1 deg apart. The horizontal line across the center of the screen represents the height of the headlamp centers from the ground. The vertical line through the center

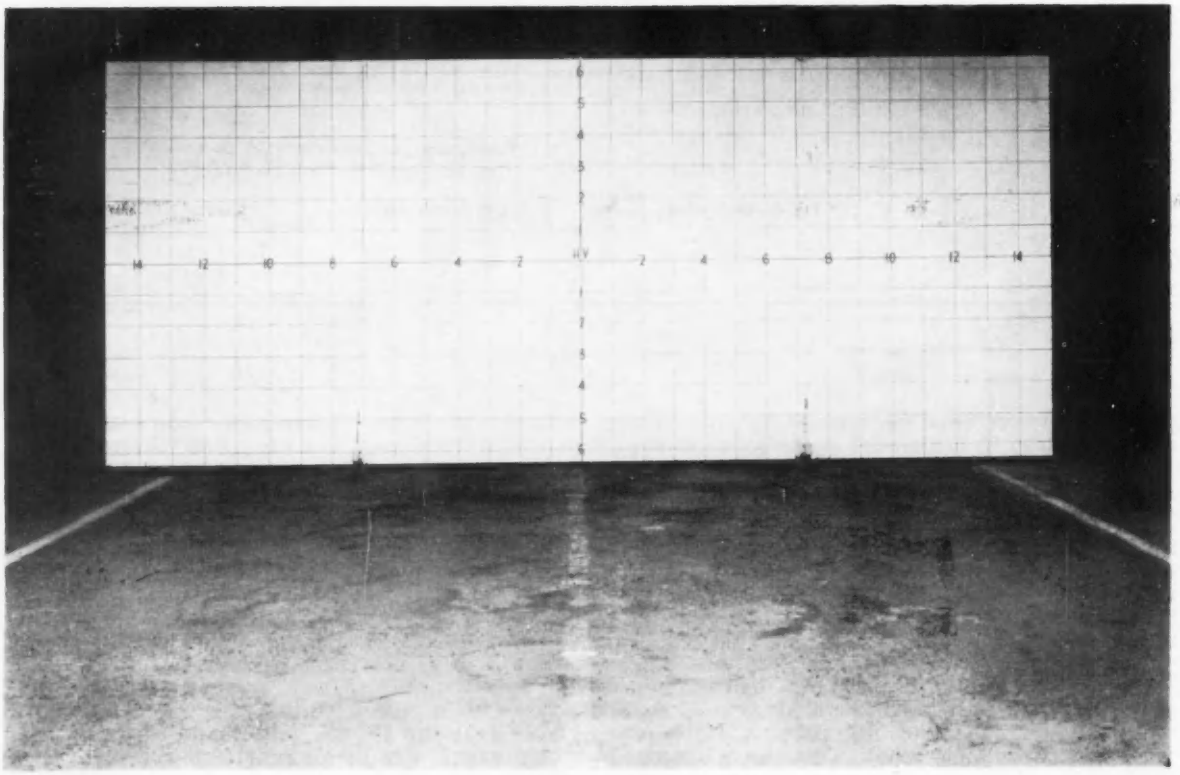


Fig. 7—Laboratory Screen with lines 1 deg apart

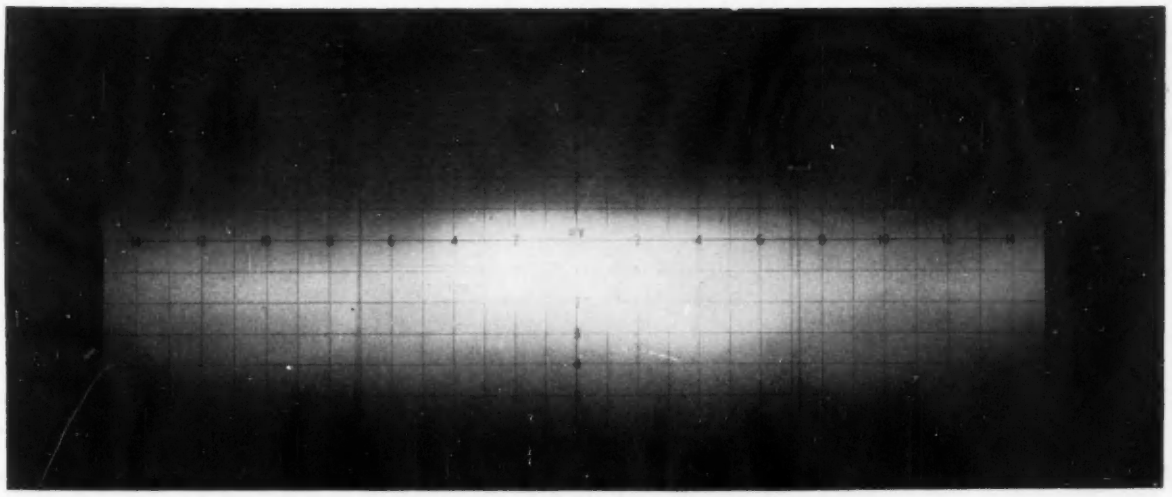


Fig. 8—Upper Beam of One 7-in. Sealed Beam Headlamp

of the screen is straight ahead of the lamp. The intersection of these two lines is of course the "H-V" point.

On a two-lane level road the average driver's eye is about ½ deg above the horizontal and about 3½ deg left of the vertical when the approaching car is 100 ft away. Farther away, the approaching driver's eye recedes toward the H-V point. On a two-lane road, for all practical purposes, it can be considered that the approaching driver's eye is at the H-V point when he is 1000 ft or more away. This picture illustrates why it is so necessary to limit the glare near the line extending from the H-V point through this point ½ deg up and 3½ deg left, for the most critical condition of meeting other cars on a two-lane road. On divided highways, of course, this situation is less critical.

Fig. 8 shows the upper beam of a *single* 7-in. sealed beam headlamp. This is a desirable beam pattern for clear road driving. It provides:

- A high intensity zone for distant seeing;
- Light to the sides for seeing around curves before you get to them;
- Needed light above the horizontal to permit seeing ahead on rolling roads;
- A graded intensity below the horizontal and to the sides evenly, to light the road surface back to the car—and the road shoulders nearby.

Fig. 9 pictures the lower beam from one present sealed beam headlamp superimposed upon the screen and the road picture. Notice particularly the point ½ deg down, 2 deg right. Considering average headlamp mounting height, this hits the road about 300 ft ahead at the right side. Also, notice this glare point at ½ deg down, 1 deg left.

The SAE specifications for the present sealed

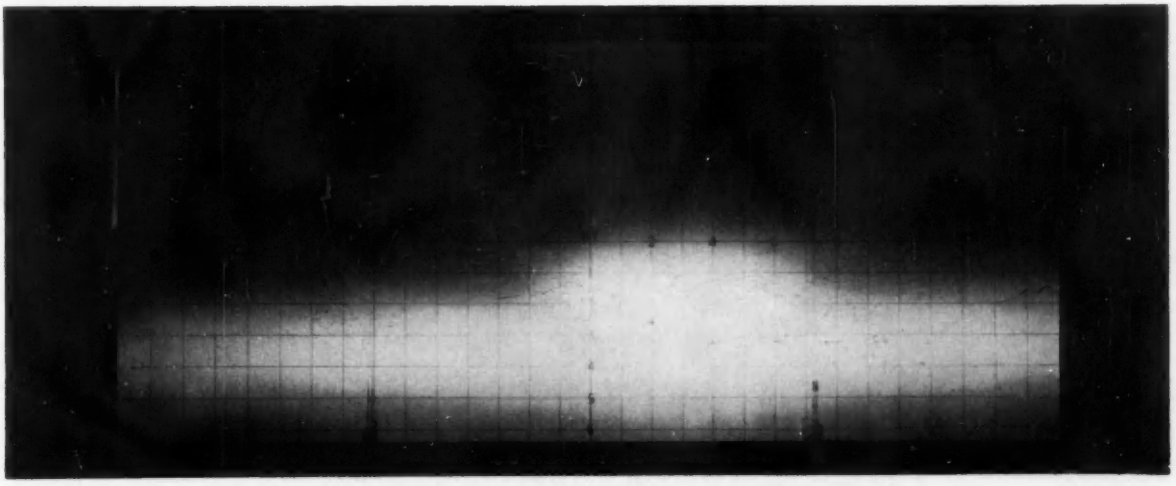


Fig. 9—Lower Beam of One 7-in. Sealed Beam Headlamp

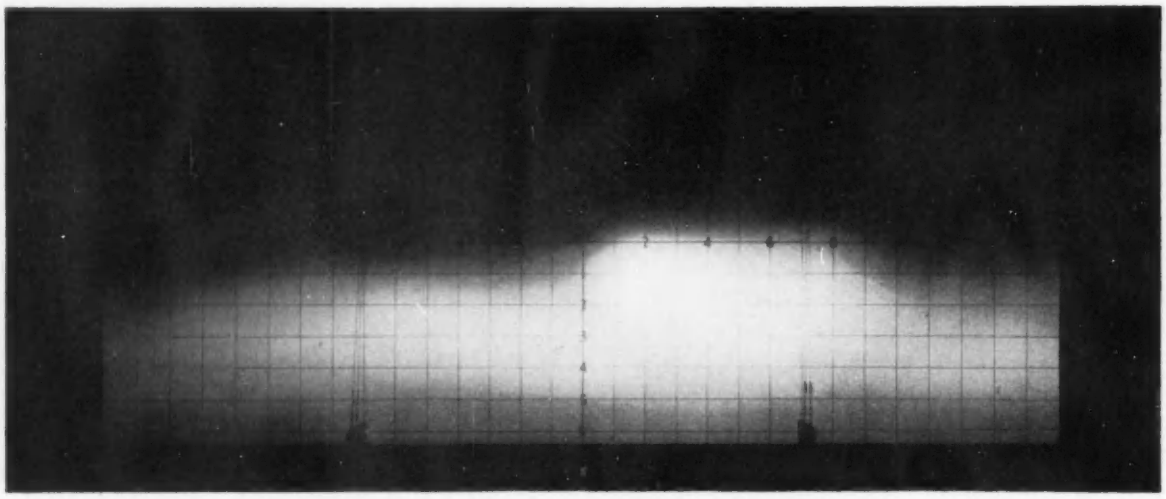


Fig. 10—Lower Beam of Single 5¾-in. Type 2 Sealed Beam Headlamp

beam headlamps call for a minimum of 3750 cp from a single unit at ½ deg down, 2 deg right, and a maximum of 2000 cp from a single unit at ½ deg down, 1 deg left.

Fig. 10 shows the lower beam provided by the Type 2, 5¾-in. unit. Note the sharper cut-off at the left. Here, the revised SAE specifications call for the same maximum 2000 cp at ½ deg down, 1 deg left—but they call for a minimum of 6000 cp at ½ deg down, 2 deg right. They also impose a maximum of 10,000 cp at ½ deg down, 2 deg right.

Chief Improvement

Herein lies the chief improvement in the lower beam of the 5¾-in. units. The average production lamps should provide almost twice as much beam candlepower at this ½ deg down 2 deg right point, which as you recall is a point about 300 ft ahead near the right side of the road. This certainly should provide improved seeing of any obstacles along the right side of the roadway. At the same time no additional *interference* glare is permitted to the left.

Fig. 11 shows the part of the upper beam supplied by this Type 2 unit,—by the second, lower filament in the trade number 4002. You will note that it provides what might be termed a "body" beam pattern, but this alone would be unsatisfactory. This upper beam is certainly compromised, as it would have been if we had simply changed the present 7-in. design to one incorporating the lower beam filament at or near the focal point.

But we can make this a very satisfactory driving beam by adding the beam from the Type 1 unit (Fig. 12) with its single filament at the focal point

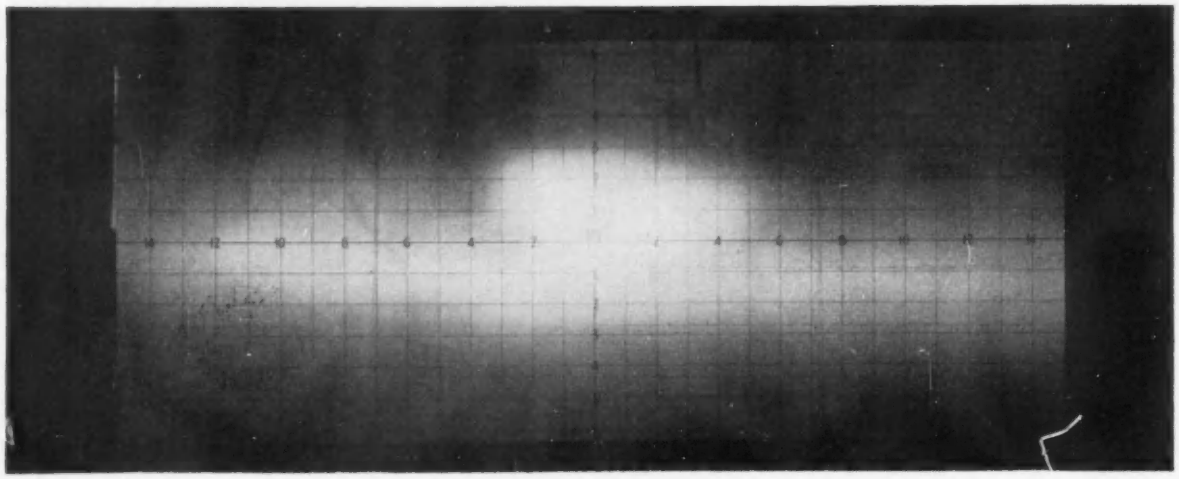


Fig. 11—Part of Upper Beam Supplied by Single Type 2 5¾-in. Sealed Beam Unit

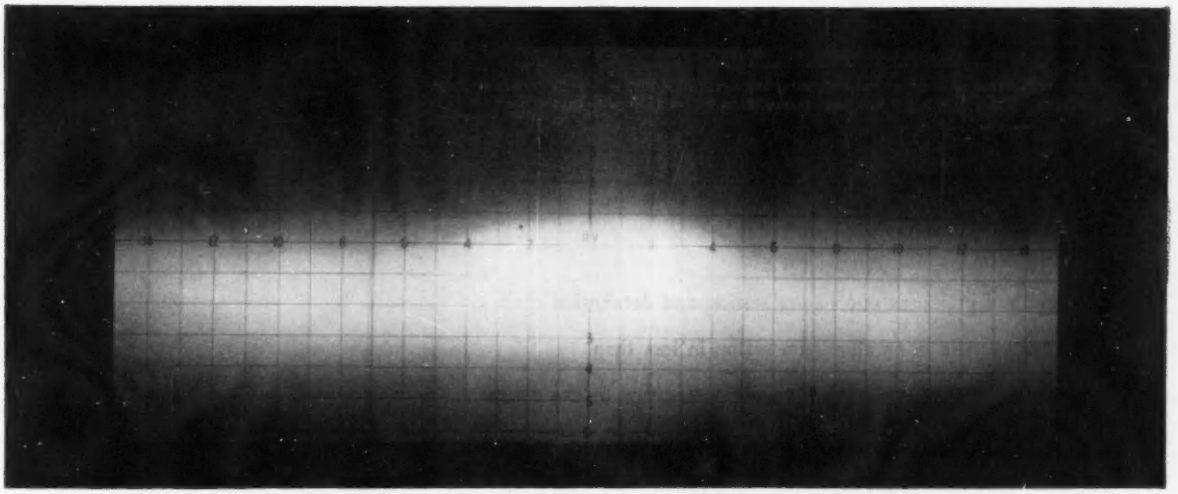


Fig. 12—Part of Upper Beam Supplied by Type 1 5¾-in. Sealed Beam Unit

which provides a high intensity zone, plus some spread light.

Composite Upper Beam Pattern

Fig. 13 shows the composite upper beam pattern provided by Type 2 and Type 1 units together.

The candlepower of the composite beam from the Type 1 and Type 2 units has not been increased above the 37,500 cp maximum established for the 7-in. units. Minimum values at the seeing points have been increased, however, and are therefore providing an upper beam which should give improved seeing results.

Production tooling of these all-glass units was a major project involving all new equipment both for pressing the glassware and for assembly of the various parts. The reflector of the Type 2 unit is doubly offset. That is, the axis is cocked both down and to the right. This permits a lens design which greatly reduces the so-called "stray" light up and to the left that would contribute to glare. Completely new automatic equipment had to be designed and built to locate the filaments accurately and automatically and assemble the parts.

Better Aiming Likely

The provision of units mechanically aimable with respect to three pads on the front surface of the lens—in combination with simple, inexpensive mechanical aimers—should result in better overall aiming performance. And these new dual sealed beam units, aimed properly, will give almost spectacular performance as compared to the old units with average service aim.

The challenge to everyone involved is to achieve exact aiming of headlamps, new or old.

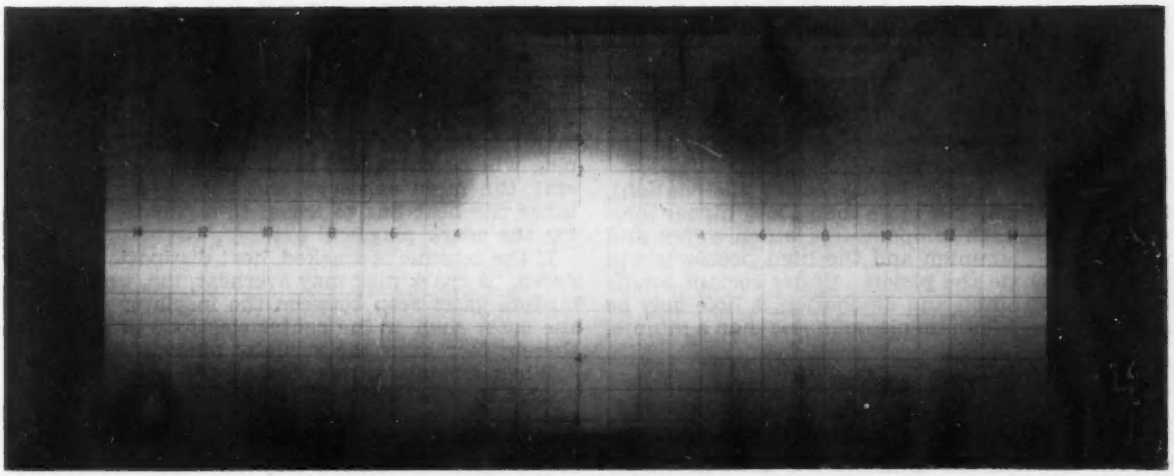


Fig. 13—Combined Upper Beam Pattern from Single Type 1 and Type 2 5¾-in. Sealed Beam Units

Jonas Anderson, Wright Aeronautical Division, Curtiss-Wright Corp.

Based on paper "Preignition in Aircraft Reciprocating Engines" presented at the SAE Annual Meeting, Detroit, January, 1956. This paper has been published in full in 1956 SAE Transactions.

Excessive heat and pressures due to preignition and detonation may burn a hole in an aluminum piston in less than a minute. By obeying operating procedures specified by the aircraft engine manufacturer, and maintaining ignition, fuel injection, and induction systems in proper adjustment, you may . . .

Stop Piston

PISTON burning may be prevented in aircraft engines if you follow the operating procedures specified by the manufacturer. For best operating efficiency, spark should be timed so that complete combustion of the fuel-air mixture occurs at or soon after top dead center of the power stroke. During cruising, when the fuel-air mixture is more lean, the spark must be advanced to compensate for a lower flame speed.

If the charge ignites before it should (preignition), the piston is exposed to hot gases longer than normal. Too, on the compression stroke these gases are compressed, raising temperatures in the cylinder even more.

If the charge ignites spontaneously (detonation), the pressures may rise more than 100% higher than normal. The high temperatures which soften and weaken the aluminum and the high pressures will eventually erode the piston. Under certain conditions of preignition and detonation, a hole may be burned in an aluminum piston in less than a minute.

What Causes Preignition?

Defective spark plugs and hot spots in the combustion chamber are probably the most prevalent causes of preignition.

Sometimes a high tension ignition system will build up voltage and discharge itself prematurely. Sometimes the automatic spark advance mechanism, which is controlled by engine speed, functions abnormally. (On new engines the flight engineer usually controls the spark advance manually, so as to get more accurate and flexible control.)

If a spark plug operates too hot it may cause preignition. If it operates too cold, it may foul out from carbon deposits during idling or low power operations.

The length of the exposed ceramic is one of the major factors which determine whether a spark plug will overheat and cause preignition. In general, the more exposure and the longer the distance the heat has to travel to dissipate, the hotter the spark plug will get.

If the ceramic is cracked, heat dissipation is hindered. A spark plug may overheat, too, when combustion gases seep between the insulator core and the outer shell or the center electrode of the plug, thereby increasing the insulator temperature.

When exhaust valves become corroded they are unable to dissipate heat quickly and soon become hot spots. Valve dome temperatures are usually about 1400 F; however, when lean fuel mixtures are used, temperatures may rise high enough to cause preignition. Tests have shown that preig-

Burning

nition will be induced when surface temperatures reach between 1600 and 1900 F.

Although combustion chamber deposits in high compression automobile engines often create hot spots and cause preignition, they apparently do not cause runaway preignition or serious damage in an aircraft engine.

Variations in fuel sensitivity and inherent resistance to preignition are also possible factors influencing piston burning.

Follow Operating Specifications

Strict observance of specified operating limits and procedures is an important factor in reducing piston burning. Proper fuel distribution and carburetor air temperature at each cylinder are probably the most critical requirements which must be met. The ignition, fuel injection, and induction systems, as well as the combustion chamber parts themselves, must be kept properly adjusted, so that abnormally high operating temperatures and pressures will not occur.

Operating temperatures are affected by:

- **engine power**
- **fuel/air ratio**
- **combustion charge temperature**
- **combustion chamber temperature**
- **spark timing**

The amount of **power** an engine produces depends on the brake mean effective pressure, the manifold air pressure, and the revolutions per minute. Therefore, accurate instruments and gages to measure these conditions are very important. Too, there must be control to maintain equal power load on all cylinders so that no cylinders are overloaded.

Fuel/air ratio is a very sensitive factor. If a lean fuel/air ratio is used during take-off or climbing (when rich mixtures are necessary), abnormally high combustion temperatures and possibly detonation may occur. So, care must be taken not to have leaky fuel injection lines or malfunctioning fuel injection plungers.

During low-powered cruising, leaning the fuel/air ratio below stoichiometric mixture is recommended. It will ordinarily reduce temperatures and the tendency to detonate, provided distribution between cylinders is satisfactory. If there is detonation, however, it may be controlled by either enriching or leaning the mixture. (In each cylinder, detonation tends to occur near the stoichiometric fuel/air ratio.) Thus, in general, less chance of detonation as well as cooler operating temperatures can be had during cruising if the fuel/air is leaner than stoichiometric. This must not be overlooked when setting the mixture manually.

Combustion charge temperature, an important

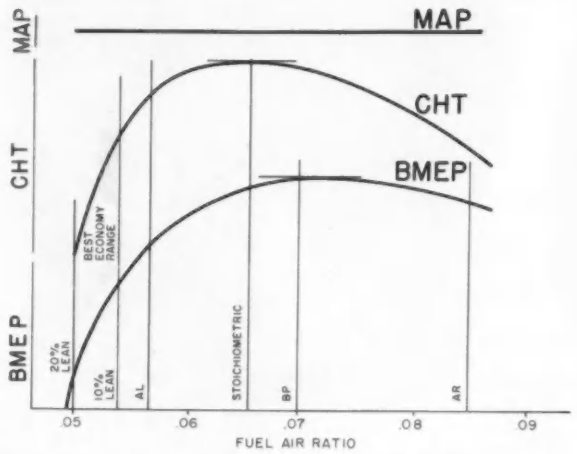


Fig. 1—At constant speed and constant manifold air pressure (MAP), power will increase as the fuel-air mixture is leaned from auto-rich. Best power (BP) point occurs near stoichiometric mixture. Further leaning will increase cylinder head temperature (CHT) and lower bmep. For cruising, a fuel/air ratio where the power is about 10% below that realized at best power conditions gives best economy. (AL = auto-lean, AR = auto-rich.)

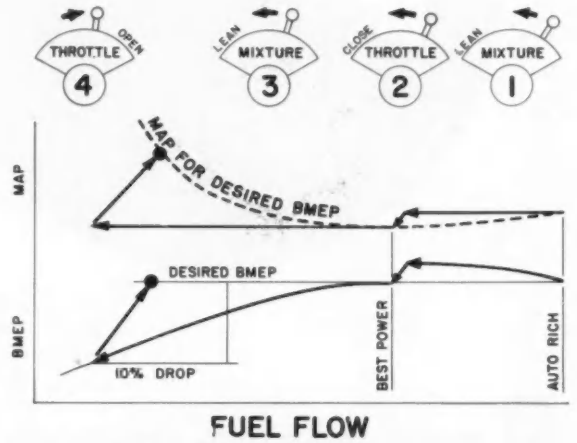


Fig. 2—Procedure for manual leaning to get desired power and good fuel economy during cruising.

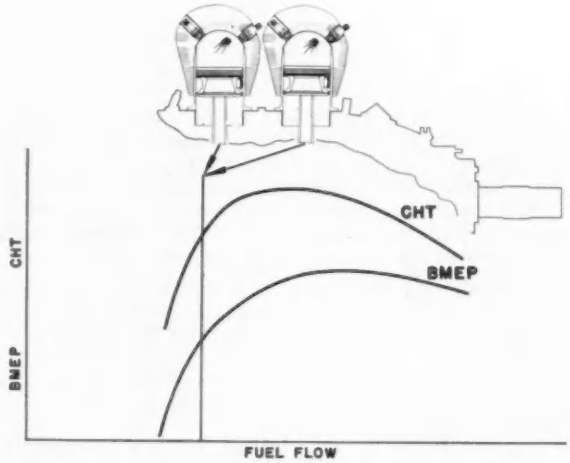


Fig. 3—A double row engine operating at 10% lean cruise condition, with equal air and equal fuel flow to both banks of cylinders, will have equal power and cylinder head temperature.

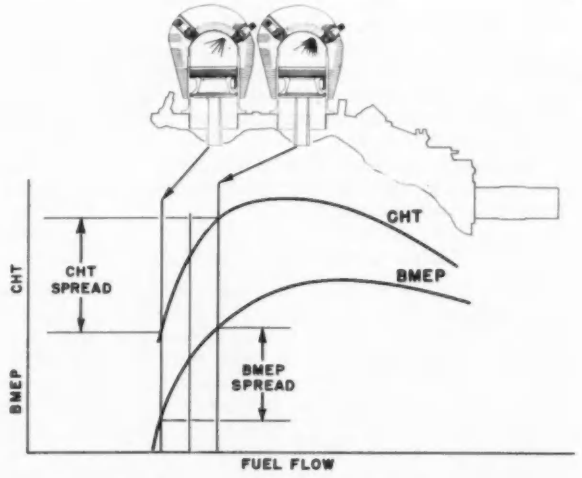


Fig. 4—The same engine with unequal fuel flow will have one bank of cylinders running richer and supplying more power than the other. Thus, higher combustion chamber temperatures and detonation may occur.

factor in causing detonation, is determined by the intake pipe air temperature—which depends upon supercharge ratio and carburetor air temperature. With a high supercharge ratio, the charge temperature tends to be high. This is usually offset by cooler carburetor air temperatures and decreased exhaust back pressure at high altitudes where the high supercharge ratio is needed.

To avoid icing of the induction system, the carburetor air sometimes must be heated. This increases the charge temperature. Therefore, the instruments for measuring carburetor air temperature should indicate an average reading, particularly if strata of hot and cool air exist.

At low altitudes the carburetor air temperature affects detonation even more than at high altitudes. At high altitudes the tendency to detonate is reduced because the lower exhaust back pressure permits the exhaust gas to be scavenged more quickly.

Combustion chamber temperature can be measured indirectly by measuring cylinder head temperature. It is true, combustion chamber internal temperatures are affected more by internal conditions than by changes in the cooling air. However, other things being equal, changes in head temperature will affect detonation. For example, during an experiment, a non-detonating, single cylinder engine which was operating over power limits was made to detonate harmfully by increasing the head temperature from 425 to 500 F.

Proper distribution of fuel to each cylinder of the engine is also a factor.

The 18-cyl reciprocating engine with fuel injection is usually equipped with two fuel injection pumps, each having nine plungers. One pump supplies fuel to the rear blank of cylinders, the other to the front bank. The length of the synchronizer bar connected to control levers on each pump controls the distribution of fuel flow to each bank. Thus, making the length of the synchronizer bar shorter than the established setting will enrich the rear bank and lean the front bank. Also, flows will be unequal if the pumps are not calibrated under similar conditions or if their control mechanisms are worn.

Leaning The Mixture

To understand the significance of unequalized fuel flow one must be familiar with variations of power and cylinder head temperatures that are experienced by a cylinder when leaning out the mixture at conditions of constant speed and constant supply of air or manifold pressure. These variations are illustrated in Fig. 1, for cruise power conditions. At the rich setting of the master control the fuel/air ratio for the whole engine is above 0.08. As the mixture is leaned the power or bmep curve reaches a peak. This point is known as the best power point. As the mixture is leaned further the cylinder head temperature continues to rise although the power will start to drop off. The temperature will peak between auto-rich and auto-lean at a point somewhere around stoichiometric mixture. On leaning further, both power and cylinder head temperatures drop at an increasing rate. For cruise operation, a fuel/air ratio where the power drop is approximately 10% below that realized at best power conditions is sometimes recommended. The fuel/air ratio corresponding to 10% to 15% drop is the approximate region for best fuel economy.

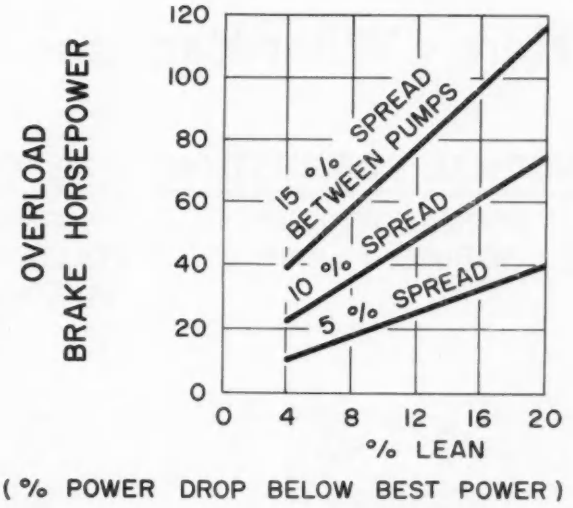


Fig. 5—Rich bank overload for various unequalized flows and leaning. Sea level, low blower, 1840 bhp/2400 rpm.

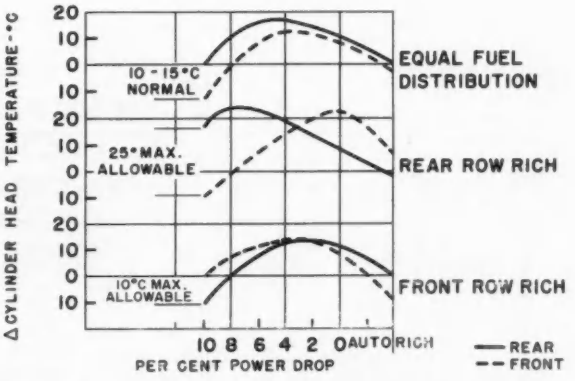


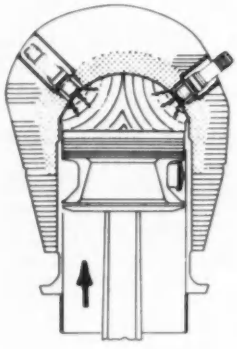
Fig. 6—Normal cylinder head temperature spread limits between cylinders in each bank at the 10% lean point.

Fig. 2 illustrates the procedure used for leaning out to the 10% lean position as the flight engineer would do it. The desired horsepower or bmep for cruise is set with the master control in auto rich. The engine speed is set and maintained constant by the propeller governor control. With fixed throttle, the mixture control is leaned out to best power. This increases the horsepower higher than desired so the throttle is retarded to bring the power back. At this point the engine is operating at best power fuel/air ratio for the desired horsepower since the

Here's What Happens . . .

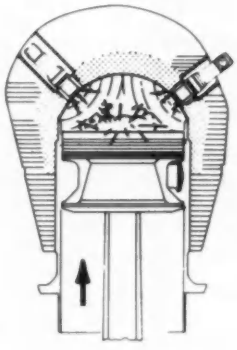
NORMAL COMBUSTION

NORMAL IGNITION
NORMAL FLAME



DETONATION

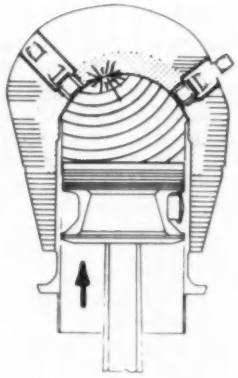
NORMAL FLAME FOLLOWED BY SPONTANEOUS COMBUSTION



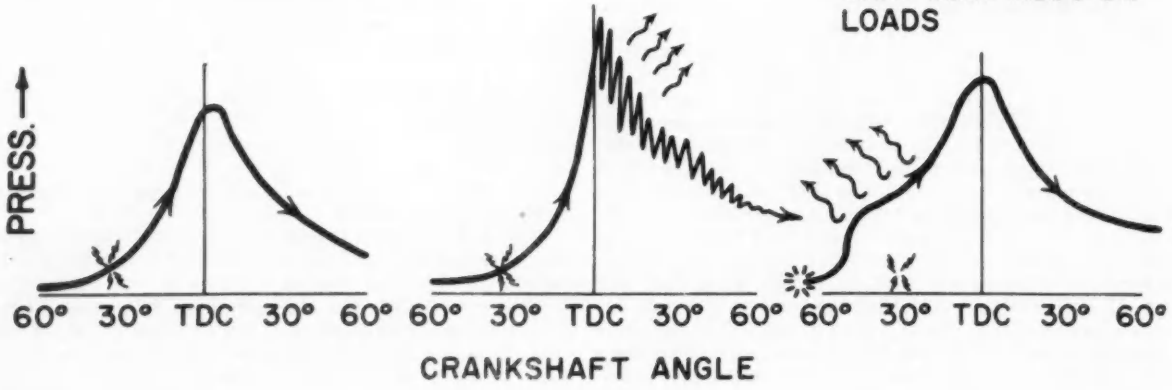
1. HIGH VIBRATORY PRESSURES
2. INCREASE HEAT DISCHARGE TO PARTS

PREIGNITION

IGNITION IN ADVANCE OF NORMAL SPARK



1. EXCESSIVE HEAT DISCHARGE TO PARTS
2. INCREASE PEAK PRESSURES
3. LOSS OF POWER, HIGH COMPRESSION LOADS



master control maintains a constant fuel/air ratio. The mixture control is then leaned out further with the throttle and MAP constant until a 10% drop is indicated on the bmep gage. The throttle is then opened to increase the MAP and to regain the power lost. Here again the fuel/air ratio will remain approximately the same. This point is called 10% lean. Note the shape of the MAP curve for desired bmep. If the engine were leaned out further to, say, 20% power drop, the manifold pressure would have to be increased considerably to regain the additional power lost.

Double Row Engine

Consider now a double row engine operating at approximately the 10% lean cruise condition. For simplicity of discussion we will assume equal air distribution between all cylinders of the engine. With equal fuel flow between cylinders of the two banks, each will be operating at the same fuel/air ratio as illustrated in Fig. 3. This would mean that the power and the cylinder head temperature would be the same for each (excluding other installation variables). The fuel flow as indicated in the cockpit of the airplane would indicate twice the flow for each bank of cylinders.

Changing the synchronizer bar or unequalizing the fuel flow by any other means causes one bank of cylinders to run richer; that is, closer to stoichiometric than the other. It will also run hotter and supply more power than the lean bank. All three of these factors tend to cause higher combustion chamber temperatures and possible detonation. If leaning beyond 10% is done, say to 20%, with the same unequalization of fuel pumps, the difference in power and temperature between the two banks will be amplified, as shown in Fig. 4.

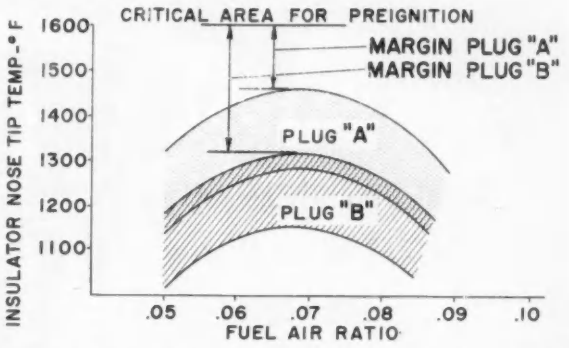
The overload brake horsepower that the rich bank would sense for various conditions of percent leaning and for various percentages of unequalized bank-to-bank fuel flows is shown in Fig. 5. Note that with a 15% fuel flow spread and at 20% leaning, the rich bank of cylinders is operating with an overload of 115 bhp. This is as though the engine were rated 230 hp higher than it is.

After extensive work with various airlines, normal cylinder head temperature spread limits were established between cylinders in each bank at the 10% lean point so that bank-to-bank fuel distribution checks could be made. These are shown in Fig. 6. Installation cooling differences between the two cylinders of each row were recognized in establishing these limits. Thus, for equal distribution, the rear row cylinder would read 10 to 15 C hotter than the front row. A 25 C maximum spread with the rear head hotter was established as a limit for the rear row rich. For a limit of front row rich, the maximum spread was set at 10 C with the front head hotter.

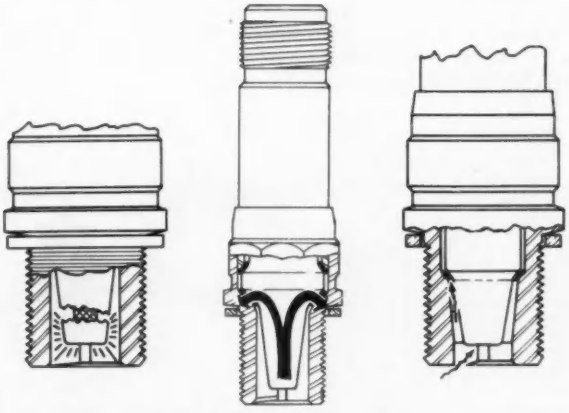
Other Changes Made

In addition to controlling bank-to-bank fuel distribution better, it should be mentioned that other changes were made which may have contributed to the reduction of piston burning, such as reduction of cowl flap openings to insure cooling in the event of incorrect cylinder head temperature readings, reduction in spark ignition advance, correction of bmep gage calibrations, improvements to fuel injection pump calibrations and control mechanisms, and elimination of leaning in excess of 10% which aggravated bank-to-bank power spreads when unequalized distribution was present.

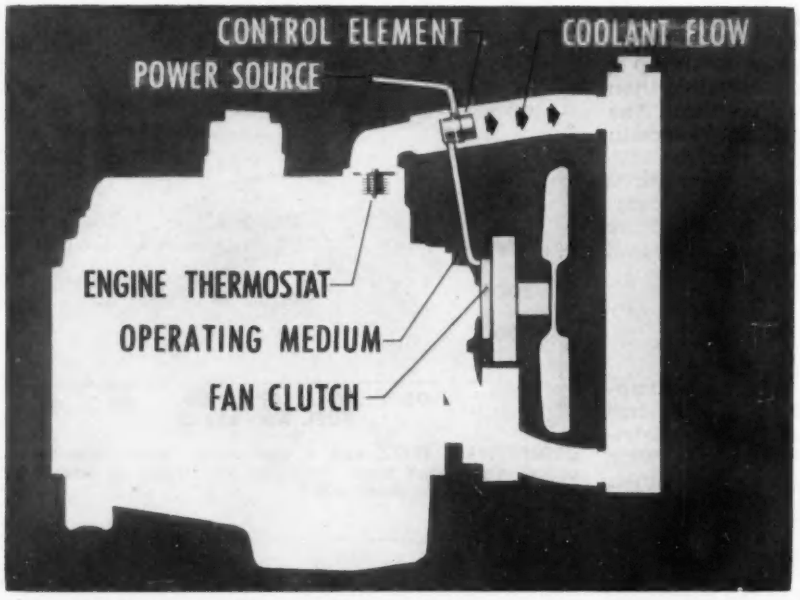
(For complete paper on which this abridgment is based, write SAE Special Publications Department, 485 Lexington Avenue, New York 17, N. Y. Price: 35¢ to members, 60¢ to nonmembers.)



COOLER SPARK PLUGS have a larger margin before temperatures critical to preignition occur. Preignition will normally be induced at surface temperatures above 1600 F.

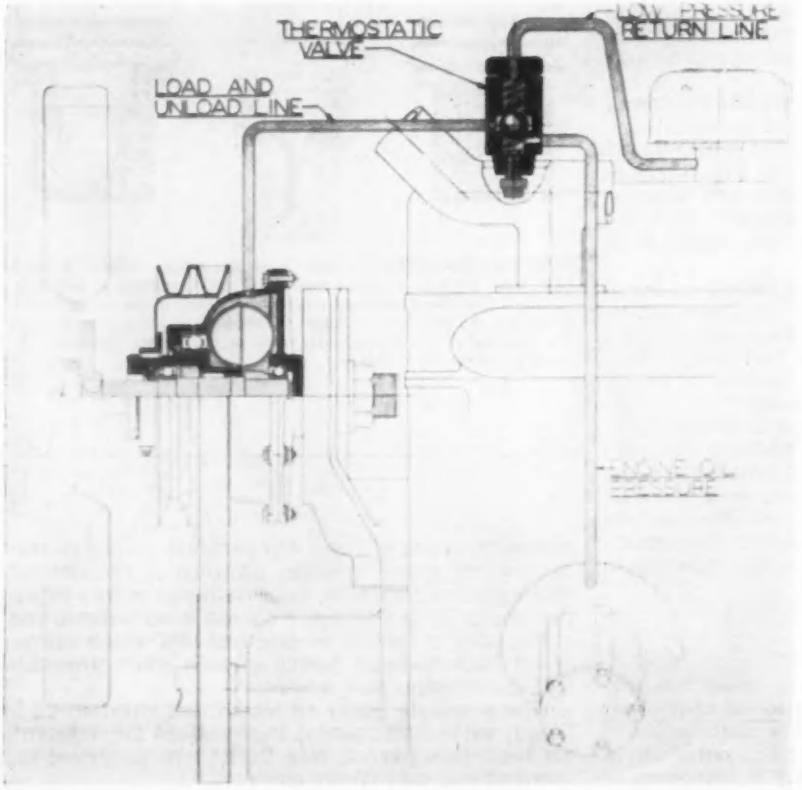


DEFECTIVE SPARK PLUGS may cause preignition. (Left) A spark plug with cracked ceramic traps heat and becomes a hot spot. (Center) The longer the heat must travel before it can be dissipated, the hotter the plug gets. (Right) If combustion gases seep between the insulator core and the outer shell or the center electrode, the insulator temperature rises.



AUTOMATICALLY CONTROLLED FAN has a control element immersed in the engine coolant which sends an actuating medium (air, oil, or electricity) to the fan clutch. When coolant reaches a predetermined high temperature the clutch engages and the fan is driven. When temperature drops to a predetermined low level, the clutch disengages and the fan blade is allowed to run freely.

On-Off



FLUID COUPLING type of fan has a thermostat - controlled two-way valve in the cooling system which senses engine water temperatures. Valve controls oil flow from an engine oil pump into a fluid coupling between the fan blade and the drive pulley. When there is no longer need for fan cooling, the valve causes the fluid coupling to empty, disengaging the fan.

Fans Save Horsepower

Engine fans may absorb up to 15 hp in large passenger cars and up to 24 hp in many trucks. But fan cooling is actually required only about 5 to 8% of the time.

ENGINEERS are trying to devise ways of using a fan efficiently and noiselessly when an engine needs cooling and disconnecting the fan automatically when it is not needed. With such "on-off" fans they expect many advantages:

- Less power will be wasted, thereby lowering fuel costs or increasing accelerating ability.
- Less fan noise.
- Quicker engine warm up.
- Longer engine life due to operating in a favorable temperature range.

There are several types of "on-off" fans now in use or being developed.

One type automatically disconnects from the engine at a predetermined engine speed. Thus, when the vehicle is traveling at high speeds and cooling air is flowing freely through the radiator due to forward motion, engine power is not wasted on running the fan needlessly.

Another type fan has a variable speed drive which reduces fan rpm as engine rpm increases.

Still another type has variable pitch fan blades that decrease airflow as engine speed increases.

However, controlling the fan according to engine speed has disadvantages. There are times, such as when hauling a heavy load, that vehicle speed is slow and engine speed is high. The fan will declutch just at the time when it is most needed to keep the engine from overheating. Too, in cold weather, the fan will operate at low engine speeds and may overcool the engine or make it more difficult to warm-up.

It is probably better to control the fan according to the engine's water temperature. Thus, a thermostatic fan will operate only when engine temperature is high, and "declutch" when the engine is cool.

Instead of an "on-off" fan, best results for trucks may be obtained if the fan speed is varied according to cooling requirements. But this requires a fully

The Authors

This article is based on papers presented at the SAE Annual Meeting, Detroit, January, 1956 by the following authors:

H. A. Reynolds
Harrison Radiator Division, GMC
Effect of Fan Design on Cooling Index, Horsepower, and Noise

D. F. Lemaux
GMC Truck and Coach Division
Temperature Control Fan Drive

K. A. Beier
Schwitzer Corp.
Some of the Reasons for Inefficient and Noisy Automotive Fan Installations

J. H. Booth
Thompson Products, Inc.
Hydraulic Fan Drive

R. W. Wantin
Ford Motor Co.
Automatic Fan Control

and discussion by

F. A. Hiersch
Continental Aviation and Engineering Corp.

modulated fan drive, which has not yet been fully perfected.

There is no doubt that an automatic, thermostat-controlled fan will save horsepower, but whether this saving justifies the increased initial cost of the fan has to be determined for each specific case. Best results will be obtained if the control element is designed and located correctly.

1. It must be calibrated to obtain maximum mileage with minimum fan operation.
2. It must be located where the coolant temperature is the highest.
3. It must respond to temperature changes quickly to prevent the engine from overheating.

Since the fan clutching device is the heart of the system, it should:

1. Be light.
2. Be compact so as to fit between the engine and the radiator.
3. Be adaptable to available fan blades.
4. Be powerful enough to transmit the required horsepower.
5. Be smooth and quiet.
6. Release cleanly and have no inherent drag.
7. Run cool and have a long life.

Why Some Fans Are Noisy

Poor fan design, restricted airflow, and too heavy a cooling burden may be the causes of fan noise. Modern engine compartments are often so crowded with accessories that there is not enough space for air to flow freely. Farm and construction vehicles often have front-mounted implements that block airflow to the radiator. So, the fan has a tougher job drawing the cooling air through the radiator. It must be rotated faster, thereby increasing noise.

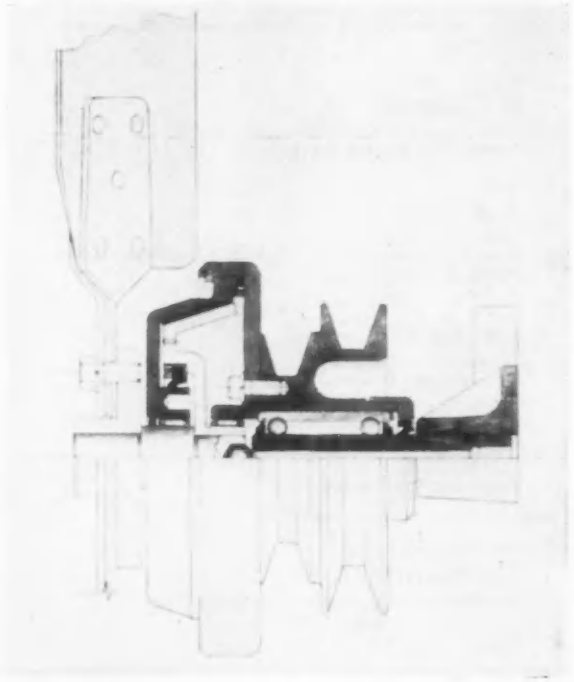
The car manufacturers' desire for small, light, inexpensive radiators also throws a bigger job on the fan. To accomplish the same amount of cooling as a large radiator the fan must draw more air through the small radiator. Therefore, it must rotate faster with subsequent noise.

Undesirable fan noises may be eliminated by careful attention to fan design details, particularly blade circumferential spacing.

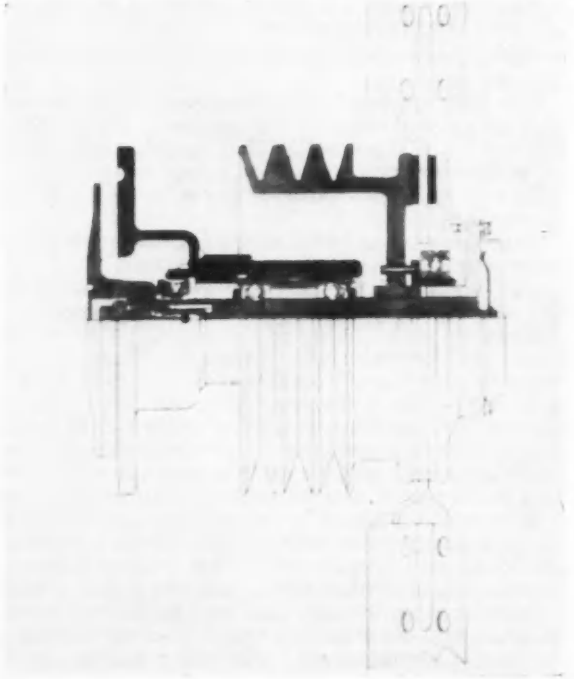
For best efficiency, a fan should be placed in a tunnel or venturi, but there is rarely space or money for this in vehicles. A shroud will prevent the air from spilling over the tips of the fan; thus more air can be delivered with less power from the engine.

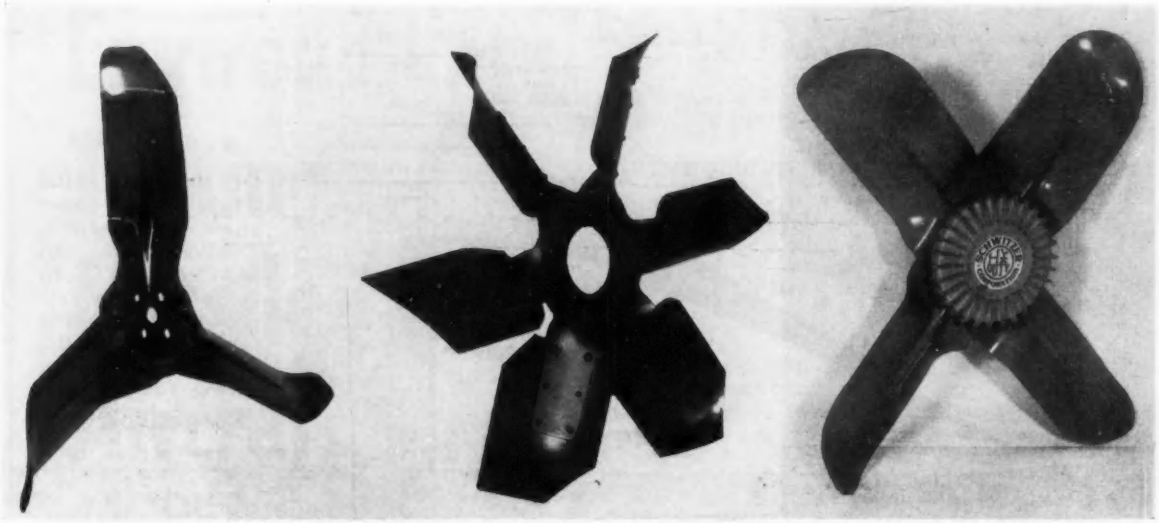
(For complete paper on which this abridgment is based, write SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

WET CLUTCH fan has a belt-driven fan housing terminating in a cone. An internal clutch cone is attached to the fan. A thermostat control valve senses engine water temperature and sends oil under pressure to the differential areas of the slidable cone clutch member, forcing it against the conical surface of the pulley-driven fan housing.

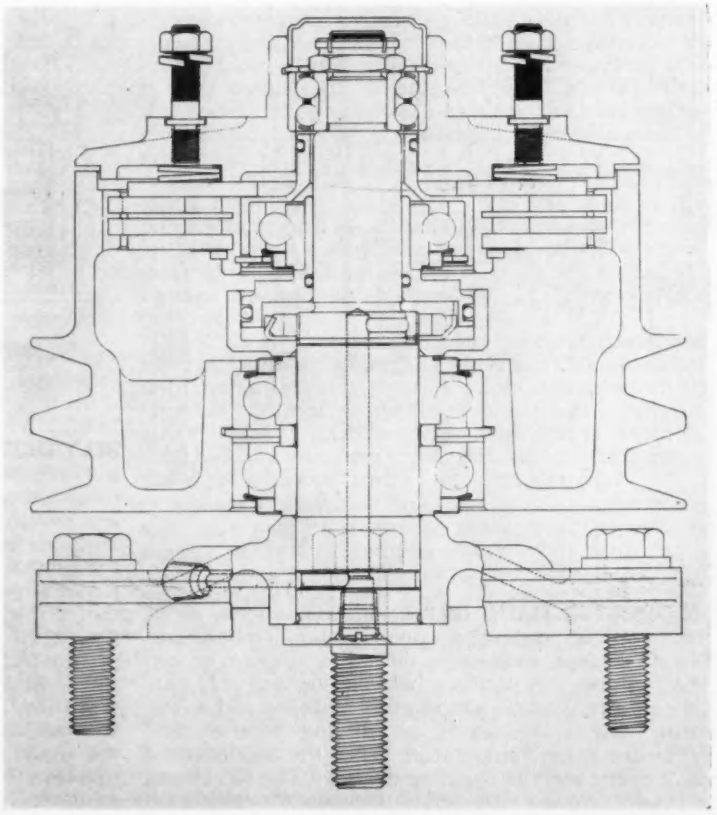


DRY CLUTCH fan floats on ball bearing between two clutch plates. Plates are operated by a pull rod connected to a thermostat in the hub of the water pump. This fan operates automatically at idle regardless of the water temperature to cover up heat overrun on a fast stop. Car tests of 40,000 miles show adequate clutch life and fuel savings of 2 mpg.



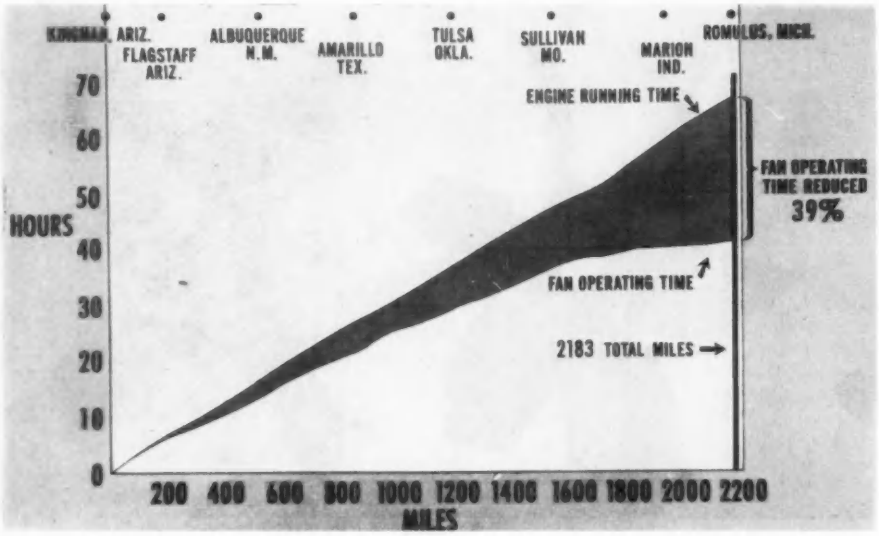


SWEPT FLOW fan discharges air about 40 deg away from the axial direction. This gives better airflow around the V-8 engine and accessories that make an almost solid wall directly behind the fan. The fan at the left has been used for many years on a passenger car; the fan in the center is used on a bus At right is a passenger car fan that operates very fast at low engine speeds and tapers off to a constant low rpm at high engine speeds. All three fans have been designed to give maximum airflow with minimum horsepower consumption.

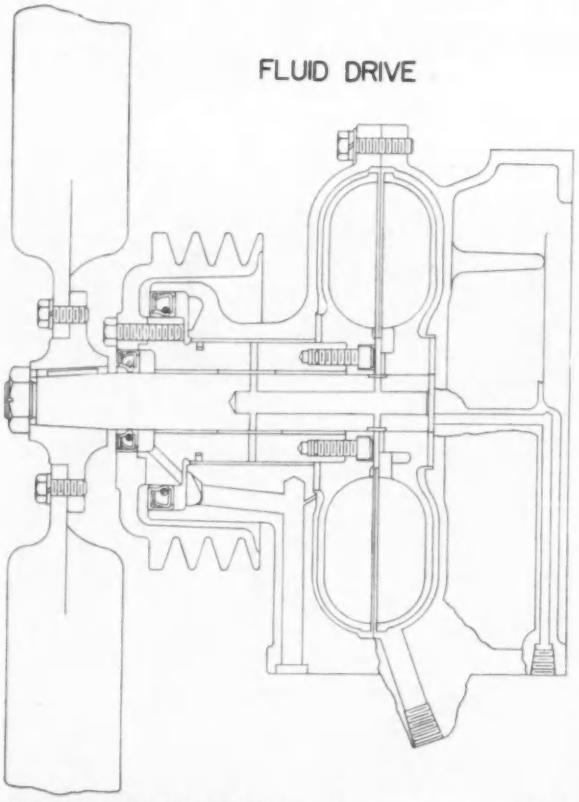


MULTIPLE DISC CLUTCH fan uses air or oil pressure to disengage the clutch when fan operation is not needed. A sensing device, called a Vernatherm, is in the cooling system. Engine coolant temperatures are maintained within 12 to 14 F.

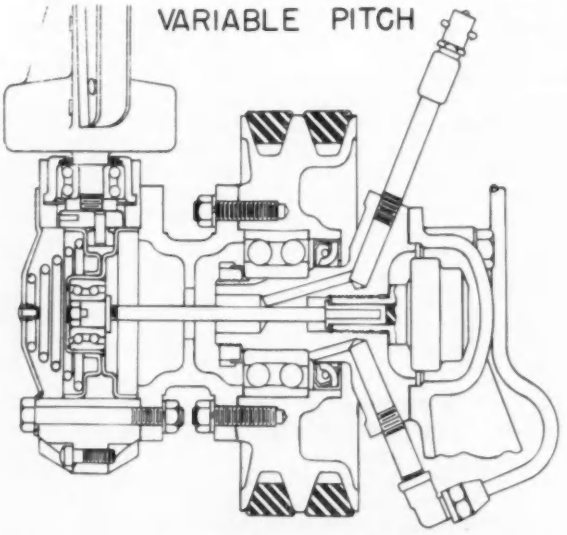
CONTINUED ON NEXT PAGE



ON A 2183 MILE TRIP of a heavy truck, the thermostat-controlled fan didn't operate 26 hr out of 67 hr engine operation. Since the fan consumes on the average 11 hp, the saving for the trip was 286 hp-hr.



MODULATED FLUID DRIVE fan retains some oil in the coupling, depending upon water temperature. The fan speed modulates with the amount of oil. The fan does not oscillate between on and off, thus giving more gradual temperature changes and eliminating any shock loads on driving mechanisms. When the water temperature cools, the thermostatic valve opens and the coupling dumps. The fan ceases to rotate. Power absorbed by slippage is negligible.



BELT-DRIVEN, VARIABLE-PITCH FAN consists of a two-piece housing in which six fan blades are mounted on double rows of bearings. A bell crank and movable sleeve at the inner end of the fan blade arms varies fan blade pitch. Power comes from a thermostat in the fan pulley spindle through an adjustable push rod. A water pipe from the water outlet manifold runs to the fan thermostat. When the engine is cold the fan blades have a slight reverse pitch which forces warm air from the engine through the radiator, speeding warm-up. When the thermostat measures 168 F, the push rod is forced toward the fan blade housing, which exerts a force against the thrust bearing and causes the fan blade pitch to increase to a maximum at 192 F. When water temperature falls below 192 F, pitch is reduced. END

Environmental Testing of Missiles and Aircraft

at So. Cal. Research Seminar

These abridgments . . .

. . . are from papers presented at the SAE Southern California Aircraft Research Seminar on Environmental Testing of Aircraft and Missiles, University of California, Los Angeles, Dec. 5-7, 1955.

1. Space Travel
   Lt. Col. F. K. Everest, Jr. ..... **page 71**
2. How To Live With MIL Specs
   Bernard P. Moser ..... **page 72**
3. Inadequate Environment Data Limit Aircraft Design
   Ray M. Daniel ..... **page 73**
4. Why Qualification Tests?
   R. J. Garon ..... **page 73**
5. Air Force Test Requirements
   John R. Grimm ..... **page 74**
6. Lab Tests Simulate Kinetic Environment
   Robert R. Beachler, Jr ..... **page 74**
7. Systems Environmental Tests Are Worth While
   F. B. Cole, Jr. ..... **page 75**

The abridgment of an eighth paper, "The Philosophy of Reliability" by **Charles T. Morrow**, appeared on page 48, SAE Journal, June 1956.

The eight papers presented at the seminar are available in full, in multilith form, as SP-141 from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: $3.00 to members, $6.00 to nonmembers.

Space Travel . . .

. . . is being held up by many complicated problems which must be solved before safe space flight becomes a reality.

Based on paper by **Lt.-Col. F. K. Everest, Jr.** USAF

THERMAL, control, and human problems must be solved if space travel is to become a reality.

Metals must be produced that can withstand the extreme heat associated with space travel and at the same time protect the occupants that are inside. For example, when flying at Mach 2, temperatures of about 360 F are expected, and when flying at Mach 3, temperatures of 1020 F are anticipated. As the Mach number goes still higher, the temperature will further increase. Thus, the problem becomes one of some consequence.

There are not too many metals, if any, in existence at this time that can withstand the stress encountered with the great differences in temperature experienced. Further, some metals will decay or lose their temper after being subjected to high temperatures. Naturally, the results of metal decay would be disastrous.

There are control problems that must be solved if space travel is to become a reality. Present control systems are not capable of controlling an airplane in rarefied air. Even with some of the research airplanes, such as the Douglas D-558 II and the Bell X-1 series, there have been hazardous control problems at altitudes of 70,000–90,000 ft, which are low relative to "space."

What will happen to an airplane that falls at high speed into the atmosphere? Will the high forces destroy it, the pilot, or both? Perhaps not from the altitudes we are now able to reach, but how about later when 200,000 ft, 500,000 ft, and even higher altitudes are reachable? This too, is a very definite problem.

Another big problem is that of crew and passenger survival in case of emergencies. The full and partial pressure suits in use today are not compatible with long life. The partial pressure suit is useful for only a few hours at altitudes where the suit is required. Full pressure suits are not developed that will guarantee safety when used at required altitudes.

In addition, neither the full nor the partial pressure suit permits adequate movement to perform normal cockpit procedures easily. The comfort of these suits is practically nonexistent, which leads to high fatigue level and poor mental attitude. The result is poor crew effectiveness. Better protection for loss of cabin pressure must be provided.

Also, there is a large problem of survival in emergencies resulting in bail out or loss of control of the airplane prior to re-entering the atmosphere. The

temperatures involved when re-entering the atmosphere are tremendous, and re-entry must be accompanied only under controlled conditions. Bodies, be they airplanes or men, must either "bounce" or re-enter on a tangent to keep from melting. Crew members, at this time, can return only in the carrier itself. This and many other problems, such as protection from radiation and bombardment from meteorites, must be solved if safe space travel is to become a reality.

At the So. Cal. Aircraft Research Seminar

How To Live With MIL Specs . . .

. . . Cut down on unnecessary MIL Spec references – they result in excessive weight, greater cost, unreliable service features, and unnecessary testing time for the product.

Based on paper by **Bernard P. Moser** Adel Precision Products, Division of General Metals Corp.

UPON issuance of a contract to an aircraft or missile fabricating concern, the normal calculations, design, and drafting procedure routines are followed by laboratory mock-ups of the system. If the system proves satisfactory, the engineering department in conjunction with the purchasing staff issues a specification document and drawing.

These documents basically cover envelope, mounting holes, weight, functional requirements, and reference MIL specifications the design unit must meet before source approval can be obtained.

We who design equipment to meet customers' specifications have noted time and time again the wholesale reference to any and all MIL specs even remotely related to the design, function, or subsequent testing of subject unit.

This wholesale reference places burdens not only upon the design and fabricating vendor but also upon the originator of the document. The fabricator must, in some cases, over-design and over-complicate a component to insure meeting any and all buried detailed requirements as outlined in the referenced MIL specs. This chain reaction continues on to the originator of the document in the form of excessive weight, excessive cost per item, unreliable service features, and unnecessary testing time.

Some leading airframe fabricators have recognized the shortcoming of wholesale reference to MIL specs, and have placed a governor in the documents wherein the MIL specs are applicable only to the extent as specified therein.

This approach simplifies the review of customers' documents, and insures a satisfactory design in a minimum time as all pertinent design requirements are carefully segregated from unrelated requirements or general requirements normally met as routine design.

The system designer should accurately analyze the application of components both from a functional standpoint and also their true environmental exposure to insure an accurate and true laboratory evaluation and if necessary, alter or modify the limits of the test condition specified in the MIL specs.

These data should be accurately compiled and conveyed to the specification document writer who in all probability is not technically aware of all the component requirements necessary to meet service conditions.

Upon receipt of these documents at a furnished contractor's plant they are carefully reviewed by the engineering staff and the closest standard unit analyzed for conformance. It is then returned to the originator of the document with any exception necessary to facilitate use of a standard production item with proved service record.

Many times the customer will alter his requirements to gain the advantages of utilizing a production unit. However, in some cases a deviation is not possible due to special application such as extreme high temperature, unusual sequencing, or absolute zero leakage.

When this condition arises, the contractor proceeds to develop a tailor-made unit for the intended application. A semi-production prototype unit must then be fabricated for the environmental testing to simulate accurately the true material, fits, and function of a production unit compared to a special hand-made component.

This unit must first meet all the normal functional requirements at room temperature (such as pressure drop, leakage, and operating voltage), and a record must be made of all data necessary to prove compliance with the detail equipment specification, and also to provide criteria for checking satisfactory performance of the equipment undergoing environmental tests.

Inadequate Environment Data Limit Aircraft Design . . .

. . . so, a compromise must be used for predetermining, simulating, and measuring the effect of environmental conditions. A good compromise is flexible, allowing it to be modified as more environmental knowledge is realized.

Based on paper by **Ray M. Daniel** Northrop Aircraft, Inc.

THE extreme variability of conditions to which aircraft are exposed makes a knowledge of environment and its effect of considerable importance to aircraft design. Unfortunately, a severe limitation is placed upon the customer and the manufacturer because of inadequate information on either of these factors.

Environment depends upon the use of the aircraft, its climatic sphere of operation, how it is handled and stored, and its own characteristics, as well as many other factors. Few of these can currently be predetermined (in advance of original design) except on a very general basis.

Assuming knowledge of environment, knowledge of effect is equally, if not more difficult to predetermine. It depends upon the ability to simulate complex conditions and measure effect, both of which (the former in particular) pose severe technological, cost, and time problems that in most cases force compromise at the expense of completeness and accuracy.

The combination of these problems obviously precludes a high degree of accuracy in establishing environmental parameters or test procedures for design or qualification prior to test of aircraft performance in flight. It should be equally clear that a flight test program that would develop and prove design for a wide range of environmental conditions, if not ridiculous, is prohibitive from cost and delay standpoints. A compromise must be sought; one that utilizes the best knowledge, judgment, and analysis for predetermining, simulating, and measuring effect of environmental conditions, yet embodies inherent flexibility and recognition of need for modification as more accurate definition of environment is possible.

At the So. Cal. Aircraft Research Seminar

Why Qualification Tests? . . .

. . . today's aircraft and missiles are so complex that normal information feedback doesn't supply development needs. So, laboratory tests supply the needed design and operational information.

Based on paper by **R. J. Garon** Wyle Research Corp.

THE American automobile today has become a complex and highly dependable device. It arrived at this level of dependability without complicated qualification test programs. We reasonably expect a reliable 1000-hr service life. This reliability did not evolve from one circuit of the demand—design—produce—deliver method of product development but, rather, it is the result of a half-century of evolution. Fifty million American motorists are evaluating the products of our automobile industry and feeding test information back to engineering.

In the more complex aircraft field, it is true that pilots and crew are available to evaluate system performance and, to some extent, component performance. However, in the most modern aircraft with the extreme high performance requirements, pilot feed-back of information is not sufficient to cope with development needs. The result?—The process we call qualification testing. By qualification testing, we mean pre-evaluation of the component under all expected conditions of functional and environmental requirements.

In a missile there is no pilot to pinpoint difficulties and gather information. Telemetering data insofar as knowing whether or not an individual component operated satisfactorily is practically useless. Therefore, the only opportunity of getting any design information or operational information about a component is in the laboratory. Here we can apply scientific methods to examine the function of a component. There are no million motorists complaining about the windshield wiper operation; there are no pilots turning in trouble reports on de-icer systems. The designer must turn to the test laboratory for the feed-back required to evolve a satisfactory product.

At the So. Cal. Aircraft Research Seminar

Air Force Test Requirements . . .

. . . insure proper operation of equipment under various environmental conditions.

Based on paper by **John R. Grimm** Wright Air Development Center, USAF

AIR Force test requirements insure that equipment remains in good working order under such environmental conditions as:

1. High humidity
2. Fungus
3. Salt fog or spray
4. Sand and dust

The humidity requirement is generally satisfied by testing the item to a cycling type test with maximum temperature of 160 F. This test has recently been reduced in length from 15 to 10 cycles (or days). Additional correlation work of laboratory to field conditions continues.

Fungus presently requires a 28 day test to the organisms and conditions as indicated by the Air Force specifications. A 14 day test has been used to some advantage where a "go" or "no go" type test is desired. That is, the appearance of growth is cause for rejection.

Salt fog or spray is a very controversial requirement. We feel that it does have its place but must be used with caution. The test that is used was originally intended for materials. It is severe. Much thought has been given to establishing a more realistic test. Reduction of test time has been advanced, also reduction in concentration of salt. The latter approach appears to be a more practical solution, and a study is being made of this point. It is again emphasized that this requirement must be utilized with caution.

The sand and dust requirement is also being studied very critically. The test as now used is an accelerated test using a concentration higher than that found naturally. It was intended primarily to provide an insight of sand penetration into equipment. It was not intended for use in testing air breathing items such as combustion engines. A program is now underway to study this entire problem and to improve the testing methods and requirements now in use.

These are but a few of the Air Force environmental test requirements used to insure proper operation of equipment under various conditions. Others include temperature, snow, ice, hail, wind, vibration, shock, acceleration, explosive atmosphere, and a newcomer, nuclear radiation.

At the So. Cal. Aircraft Research Seminar

Lab Tests Simulate Kinetic Environment . . .

. . . although exact duplication of environment is impractical, and compromise and empirical methods must be used.

Based on paper by **Robert R. Beachler, Jr.** North American Aviation, Inc.

VIBRATION, shock, and steady-state acceleration of components and equipment caused by environment during the operation of an aircraft or missile are being simulated in the laboratory. Exact duplication of the environment is usually impractical however, and present laboratory test procedures involve compromises and semi-empirical requirements.

Vibration of an airframe, or of the equipment items mounted within, may be excited by such sources as the gas pressures and inertial forces of a reciprocating engine, exhaust and inlet turbulence and rotor unbalances of a gas turbine, resonant burning of a rocket engine, propeller unbalance, gunfiring, and aerodynamic disturbances. Vibration forces may be transmitted through the mechanical couplings of the structure of the vehicle, or they may be induced by pressure variations in the gaseous medium surrounding the equipment and structure. Since these sources may combine, and the resultant forcing function at any specific location in the vehicle may comprise a series of harmonically unrelated terms acting simultaneously in three dimensions, we can see the difficulties of exact simulation.

If we could precisely measure this forcing function at each point of interest, we would still be faced with the difficulty of reproducing it in the laboratory. Although some efforts are being made in this direction, it appears that a three-axis generator which can recreate a faithful vibration environment is far in the future. There are of course some special cases where structural geometry will restrict the excitation to a single axis, and presently available equipment will provide a reasonably exact reproduction.

Faced with these general limitations, we must turn to a more practical, but somewhat empirical, simulation. The use of single-axis generators, and sinusoidal rather than complex forcing functions, will permit us to accomplish our purposes of malfunction assessment and performance comparison without undue risk of error.

Shock is similar to vibration in the transient nature of the response of the specimen to the forcing function. Shock excitation may be caused by aerodynamic gusts or sudden maneuvers, forcible ejection of stores or missiles, landing, or taxiing over rough terrain. Also, the complete vehicle or the component may be subjected to shocks while being handled or transported. A further similarity to vibration is the generation of a vibratory response by the application of a shock forcing function to a resonant mechanical system with low damping factor.

As was the case for vibration testing, we are again attempting to assess possible malfunctions, and establish performance comparisons. Again we are forced to use empirical test procedures because we do not have adequate data on the exact in-flight conditions to be encountered, nor the equipment to reproduce accurately the real environment. The exceptions to this empiricism lie in the testing of complete vehicles for landing-impact damage, or of equipment for handling damage. Here we faithfully reproduce the environment by dropping the full-scale vehicle or the equipment at the maximum velocities or from the maximum height expected to be encountered in service, and observe the results directly.

Steady-state accelerations may occur during aircraft or missile maneuvers or launchings. With the exception of the ever-present acceleration of gravity, these accelerations are relatively easy to measure but difficult to reproduce. If the effect of acceleration on specimen performance on one axis only is desired, without regard for the other axes, three points may be readily obtained. The first point 1G, is imposed by gravity along a vertical axis when the item is in its normal attitude. The 0G point results when the specimen vertical axis is rotated 90 deg. The – 1G point is produced when the unit is exactly inverted by an additional 90 deg rotation.

For higher values of acceleration, a centrifuge is the most common apparatus, and many models are commercially available. Here the specimen is subjected to a radial acceleration whose magnitude is a function of the radius arm and the angular velocity of rotation. The radius should be large in proportion to the dimensions of the specimen, and the angular velocity should be constant throughout the complete revolution of the table or platen. The total amount and direction of the imposed acceleration is the resultant of the radial component and the vertical component due to gravity. It should be noted that rapid increase or decrease of rotational velocity may produce tangential accelerations of the specimen which are greater than the desired radial value and which may cause unanticipated effects.

Measurement of radial acceleration may be accomplished by simple measurement of angular velocity, and a knowledge of the radial distance to the center of gravity of the specimen. However, the angular velocity should be determined for small increments of rotation, as well as for an average of several revolutions, to guard against the presence of cyclic variations.

At the So. Cal. Aircraft Research Seminar

Systems Environmental Tests Are Worth While...

. . . because they increase flight safety, allow prompt design changes, are the cheapest and fastest way to study system components.

Based on paper by **F. B. Cole, Jr.** Lockheed Aircraft Corp.

THE main results of conducting preflight environmental tests on functional systems are:

1. Increased flight safety.
2. Prompt refinements in system design permitting necessary revisions to be made before entire production lots of parts are received. (This is an important economic consideration.)
3. The most economical, rapid, and practical way to study and to modify the interaction of system components when operating under adverse environments.

Let us consider first the item of flight safety. The particular emphasis here is the elimination of hazardous conditions resulting from the combination of airplane dynamic loading and adverse environment in the various stages of engineering flight tests. Careful evaluation, in the laboratory, of a functional system subjected to simulated airloads concurrent with temperatures will usually uncover any serious malfunctions or marginally safe characteristics. These laboratory tests can be accomplished before flight, and at no risk to airplane, flight personnel, or reputation.

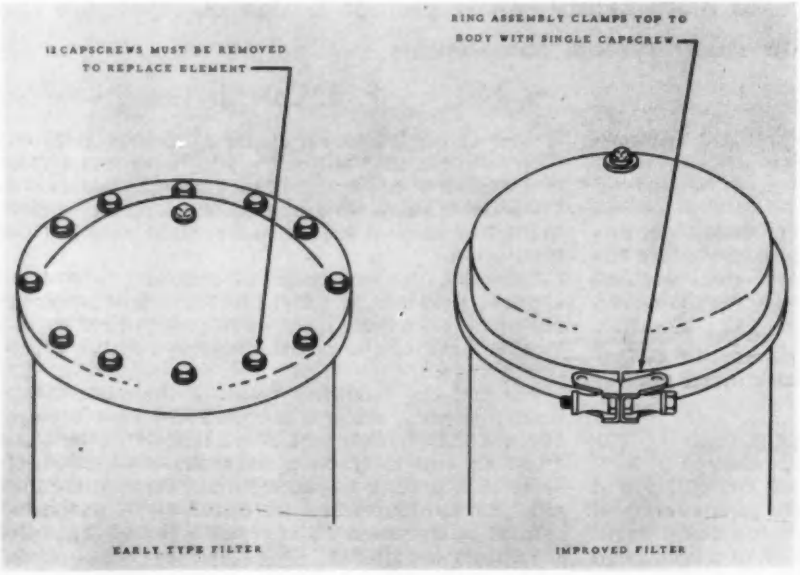
Secondly, the economics of reducing production reworks, field kits, and flight test time is of great importance. The costs involved in running system environmental tests are small compared to the potential savings.

Thirdly, the technical value of the systems approach is great when it is considered that the system stability, backlash, accumulated deflections and frictions, unit interaction, sequence of function, effects of hydraulic pressure surges, viscous damping changes, and physical failures can all be evaluated, refined, or corrected under repeatable and controlled laboratory conditions.

Tips on Design for

Much can be and should be done to design construction and earthmoving equipment to make maintenance easier and more effective. Here are six examples of how maintenance ease was or could be improved through changes in design.

These are but a few of the things that can be done in designing for maintenance. It remains for the designer to consider the maintenance problems associated with each component and piece of equipment and to design for maintenance.


12 CAPSCREWS MUST BE REMOVED TO REPLACE ELEMENT
RING ASSEMBLY CLAMPS TOP TO BODY WITH SINGLE CAPSCREW
EARLY TYPE FILTER
IMPROVED FILTER

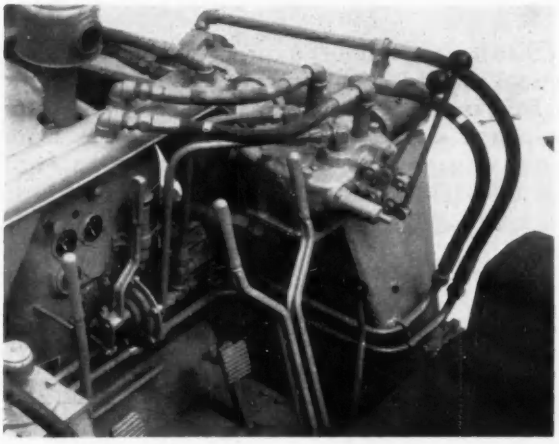
Tip No. 1

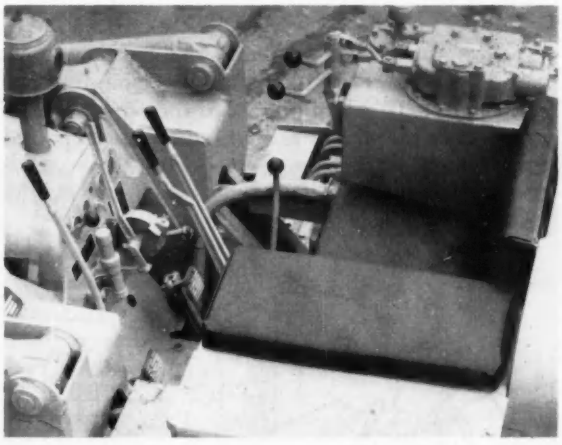
One improvement a designer of heavy duty filters has used to reduce maintenance time and facilitate quick removal of elements was to replace the bolted on cover with a clamp arrangement having a single capscrew. This saves considerable time and eliminates thread stripping.

Ease of Maintenance

H. H. Bidwell, Assistant Chief Engineer, Allis-Chalmers Mfg. Co.

Based on paper "Designing For Maintenance" presented at a meeting of the SAE Central Illinois Section's Earthmoving Industry Conference, Peoria, April, 1956.



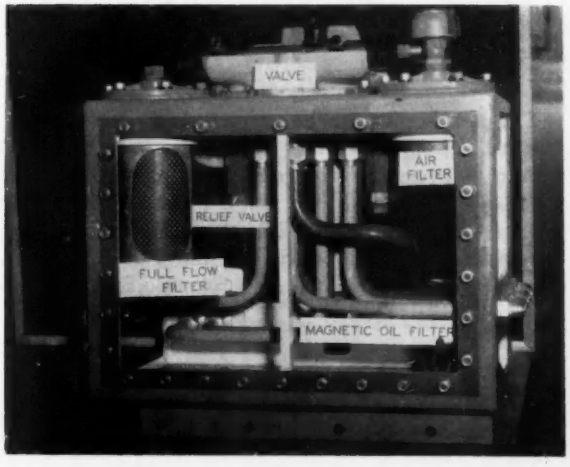


Tip No. 2

On the left is an early design of a hydraulic system using several hoses and fittings connected to the valve and tank. Note the space required and the many connections which must be kept tight to prevent leaks. On the right is a more advanced design of the same unit with improved appearance, safer operation, and increased operator's vision. Note the real maintenance simplicity and the elimination of external hydraulic hoses, fittings, and hardware from the tractor cowl and deck.

Tip No. 3

This new style hydraulic tank provides a large capacity oil reservoir and incorporates a magnetic filter, screen, and full flow filter to protect the most vital parts of the pump and valve from premature wear that would result from dirt or small pieces of metal in the system. In addition, an air filter further protects the system from intake of dust and dirt. All of these units, as well as connections to the control valve are sealed inside the tank, practically eliminating outside oil leaks and giving safe, dependable operation.



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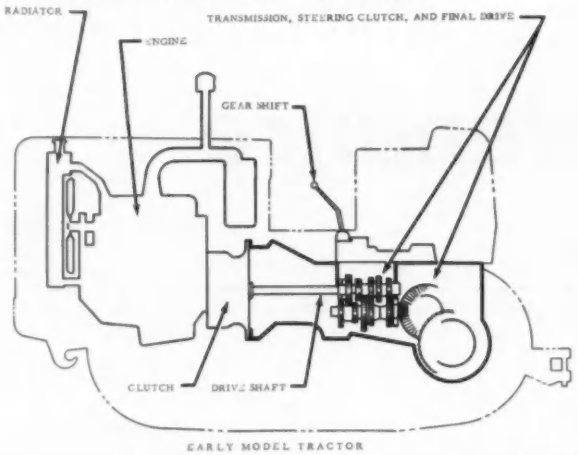
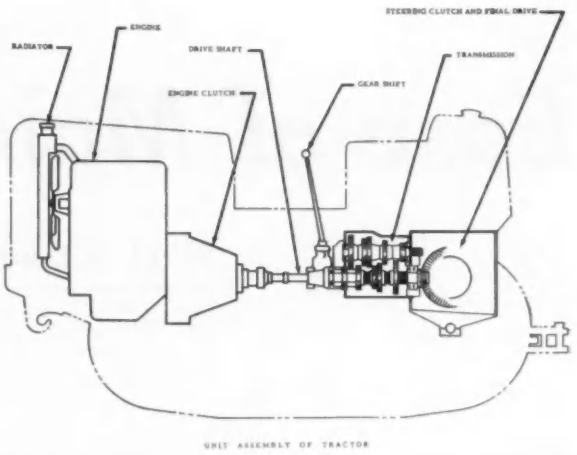


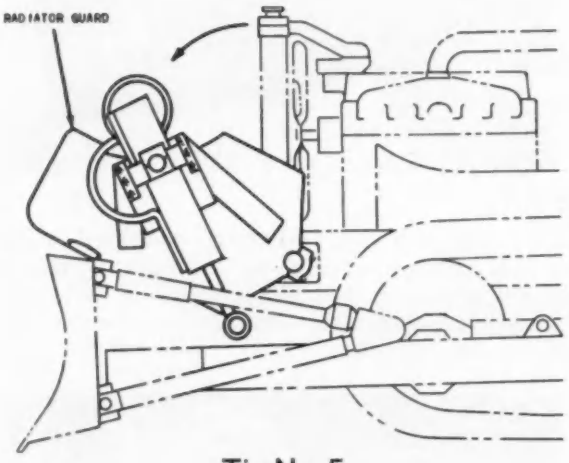
EARLY MODEL TRACTOR



UNIT ASSEMBLY OF TRACTOR

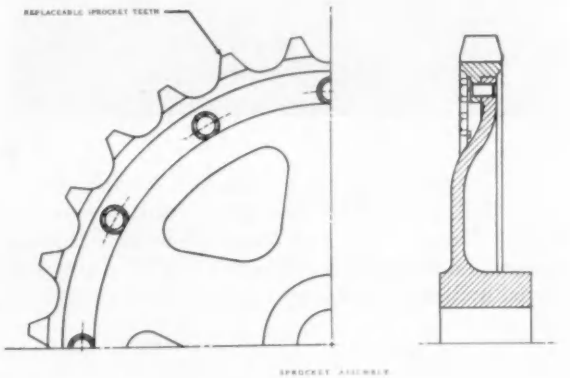
Tip No. 4

Designing the tractor to be assembled by units, rather than many assemblies incorporated into one large housing, has been one of the most outstanding contributions to production assembly and maintenance in recent years. Each component of the power train through the tractor is mounted so it can be removed separately from the tractor as an assembly and repaired or inspected in a clean shop and then replaced. Extra assemblies of the engine, clutch, transmission, radiator, and such can be held ready for replacement when repairs are necessary. This type of design is invaluable in military equipment where time is especially precious.



Tip No. 5

The cooling system usually requires frequent attention to keep free from brush, chaff, or sand and should be accessible for repairs and cleaning. The radiator guard could be made to tip forward for ease of service and still retain the cable or hydraulic equipment mounted to the guard. The equipment mountings on the guard also provide interchangeability of equipment.



SPROCKET ASSEMBLY

Tip No. 6

In order to replace a final drive sprocket it is usually necessary to remove the bearings, seals, bracket, and nuts. Then the parts must be cleaned, lubricated, assembled, and adjusted. This procedure could be eliminated if the sprocket was made into an assembly consisting of replaceable teeth attached to the hub.

(For complete paper on which this abridgment is based, write SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

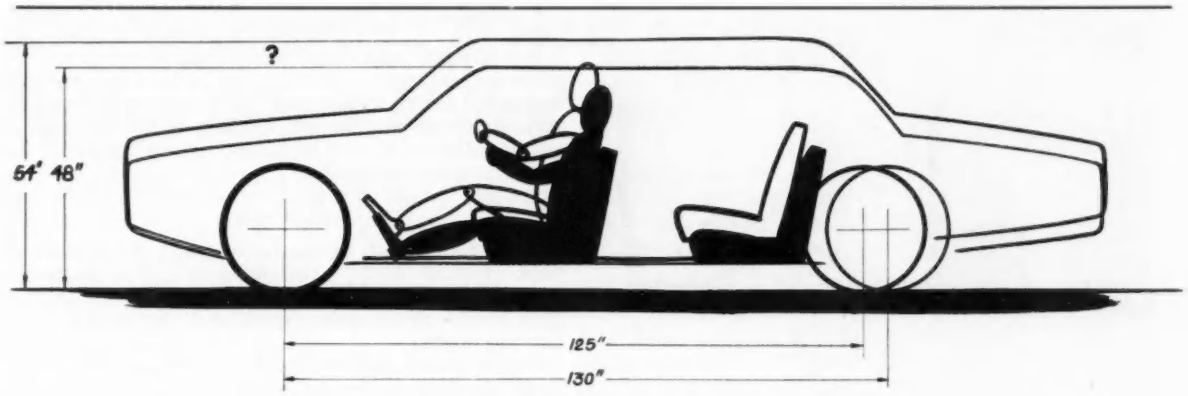


Fig. 1—Diagram of the minimum low range

Design Ingenuity Points the Way to

MINIMUM HEIGHT REQUIREMENTS

William M. Schmidt, Studebaker-Packard Corp.

Based on paper "How Low Is Low?" presented at the SAE Passenger Car, Body, & Materials Meeting in Detroit, March 6, 1956.

AIMING at a car 48–54 in. high, which is the minimum feasible height for the future, designers will be working on:

- Lower seats
- Doors in the roof
- Swivel seats
- Adjustable or telescopic steering columns
- Improved visibility
- "Pancake" powerplants

Practical progress in each of these areas lies in the foreseeable future. And the possible minimum height can't go lower because inflexible human anatomy is the absolute dictator in the establishment of the minimum low. (The average torso height is 34 in. Allowing 8 in. for seat thickness and additional headroom to accommodate taller people, plus a minimum ground clearance of 6 in., the minimum low will fall within the range of 48 to 54 in. . . . as indicated in Fig. 1.)

Lowers Seats

Seats are already evolving from the straight-back, arm-chair type to a design which—being lower to

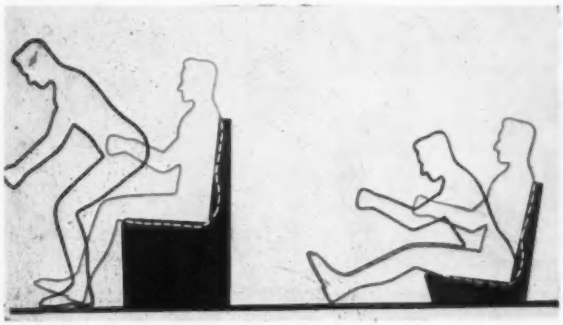


Fig. 2—Effect of evolution of seats. The legs-straight-out position improves both safety and comfort on long drives.

the floor—puts the legs in a more horizontal position.

This legs-straight-out position (Fig. 2) has two major advantages for the passenger:

(1) The horizontal position of the legs almost automatically tends to brace the body in event of a sudden stop or collision; and

(2) On long trips, the legs are more comfortable extended. (Try the two positions sitting in a chair at home with and without an ottoman on which to rest your legs.)

The detriment to this legs-out position is the knee-lifting required to actuate a conventional brake pedal. (Maybe power brakes will help this situation.)

Doors in the Roof

The lower the car, the more the doors will have to invade the roof area as indicated in Fig. 3. The extreme condition would be when the doors hinge at the centerline of the roof—as in the Mercedes 300 SL. Doors in the roof make getting into a very low car about as easy as *sitting down into* present cars.

It is already apparent that stooping or bending to enter an extremely low car would be very uncomfortable. Doors in the roof for easier entrance and exit, in other words, are a must when talking of automobiles with overall heights falling within the minimum low range.

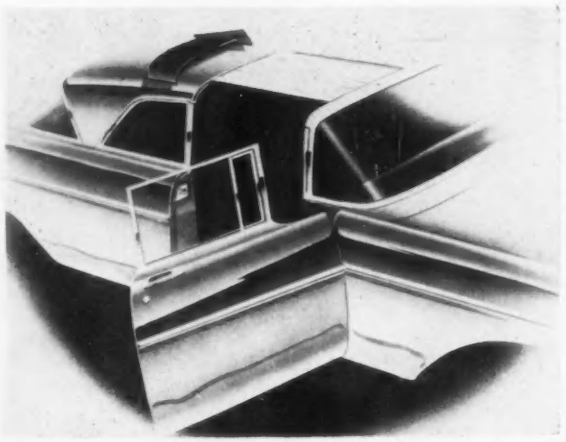


Fig. 3—Roof panels that retract into roof ("doors into roof") for easier entrance and exit are ahead. The lower the cars, the more doors will have to invade the roof area.

Swivel Seats

With compound windshields that extend farther back over the driver's compartment, it is necessary to lean back from the waist up to gain entrance. This would be necessary even in a convertible with the top down.

Use of swivel seats would easily remedy this situation. Such seats would allow the driver and passenger to sit down with their backs to the centerline of the car. Then, merely raising their legs slightly and turning to face the front of the car, they would assume a normal driving position.

Adjustable Steering Posts

Adjustable or telescopic steering posts would also be an aid to easier entrance and exit.

Improved Visibility

New visibility problems arise as the car approaches the minimum height. In an extremely low car, for instance, it would be very difficult to see around older and higher cars and trucks.

So, radar or electronic warning devices will probably be used to indicate obstructions or accidents ahead on the highway. This accessory-type item could be a great safety factor in heavy traffic on crowded expressways.

Visibility will improve as more glass is used in cars. And more and more of the driver's compartment area will be covered by glass as cars get lower. This will be done first with compound glass and then with glass on the roof. The bubble canopy *is* in the future—without question. By the time it comes, we will have glass of terrific tensile strength with either sliding or lifting access panels—or the lifting of an entire canopy. Harmful sun rays will be eliminated by gold dust or other metallic substance between the glass laminations.

Pancake Powerplants

"Pancake" powerplants with horizontal radiators are likely to be a factor permitting the hood to be lowered on these minimum height cars. Gas-turbines and atomic-reactor type powerplants are also in the not too distant future. Someday you may buy your powerplant at the neighborhood capsule dealer!

How Low Is Low?

Trends and evolutionary factors which have influenced the height of automobiles in the past will continue to do so in the future. And, eventually, public acceptance will determine the answer to the question: How Low Is Low?

(For complete paper on which this abridgment is based, write SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

SAE Headquarters Moves To New Offices In New York

ON Oct. 8, 1956, the new address of the SAE New York headquarters will be:

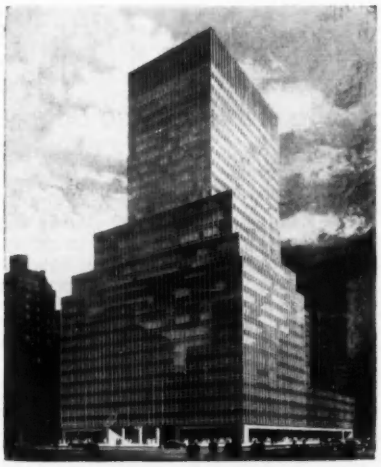
485 Lexington Avenue
New York 17, N.Y.
Tel: OXford 7-3340

The larger and more modern offices, which will accommodate all members of the headquarters staff on the same floor, will be on the fifth floor of a new building between 46th and 47th Streets on Lexington Avenue, New York City.

The editorial offices and New York advertising office of SAE Journal and Transactions will also be at the new address.

Council sees these new quarters as a necessary tool in equipping the Society with effective facilities for continuing and extending SAE services immediately and in the future.

In a letter to SAE members announcing the move, President George A. Delaney stated that he was particularly pleased because "it will give SAE adequate space for headquarters operations to serve a growing membership in changing and expanding services."



SAE headquarters will be located on the fifth floor of this building at 485 Lexington Avenue, New York City

SAE National Meetings

1956

October 2-6
Aeronautic Meeting,
Aircraft Production Forum,
and Aircraft Engineering Display
Hotel Statler, Los Angeles, Calif.

October 10-12
Transportation Meeting
Hotel New Yorker
New York, N. Y.

November 1-2
Diesel Engine Meeting
The Drake, Chicago, Ill.

November 8-9
Fuels and Lubricants Meeting
The Mayo, Tulsa, Okla.

1957

January 14-18
Annual Meeting and
Engineering Display
The Sheraton-Cadillac
and Statler Hotels
Detroit, Mich.

March 5-7
Passenger Car, Body, and
Materials Meeting
The Sheraton-Cadillac
Detroit, Mich.

March 20-22
Production Meeting and
Forum
Hotel Statler, Buffalo, N. Y.

April 2-5
Aeronautic Meeting,
Aeronautic Production Forum,
and Aircraft Engineering
Display
Hotel Commodore,
New York, N. Y.

June 2-7
Summer Meeting
Chalfonte-Haddon Hall
Atlantic City, N. J.

August 12-15
West Coast Meeting
Olympic Hotel, Seattle, Wash.

September 9-12
Tractor Meeting and
Production Forum
Hotel Schroeder
Milwaukee, Wis.

October 1-5
Aeronautic Meeting,
Aircraft Production Forum,
and Aircraft Engineering
Display
Ambassador
Los Angeles, Calif.

Douglas . . .

. . . to Receive 1956 Sperry Award.

DONALD W. DOUGLAS, president of Douglas Aircraft Co., will receive the 1956 Elmer A. Sperry Award "in recognition of his distinguished engineering contribution which has advanced the art of transportation through the development and production of the 'DC' series of airplanes." He will be presented with a bronze medal, certificate, and an honorarium, during the SAE National Aeronautic Meeting, Los Angeles, Oct. 5, 1956.

Robert B. Lea, chairman of the Elmer A. Sperry Board of Award will make the presentation on behalf of the four sponsoring engineering societies: the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the Society of Automotive Engineers, and the Society of Naval Architects and Marine Engineers.

Mr. Douglas has pioneered in many fields of aviation but is perhaps best known throughout the world for the "DC" series of airplanes, including the famous twin-engine DC-3, backbone of commercial airlines for a decade.

This will be the second annual presentation of the Sperry Award, which, according to its character, is given for "a distinguished engineering contribution which, through application proved in actual service, has advanced the art of transportation whether by land, sea, or air." It was awarded in 1955 to the naval architect and engineer, William Francis Gibbs, designer of the ocean liner S.S. United States.

The award was founded to commemorate the life and achievements of Elmer Ambrose Sperry, whose inventions and activities in many fields of engineering benefited all forms of transportation.

Wislicenus . . .

. . . is winner of 1955 Manly Award.

GEORGE F. Wislicenus, director of the Garfield Thomas Water Tunnel, the Pennsylvania State University, will be awarded the SAE Manly Memorial Medal for 1955, at the SAE National Aeronautic Meeting, Oct. 4, 1956, in Los Angeles.

The Manly Award honors the "author of the best paper relating to the theory or practice in the design or construction of, or research on, aeronautic powerplants or their parts or accessories, which was presented at a meeting of the SAE."

Wislicenus' paper, entitled "Principles and Applications of Bypass Turbojet Engines," which was presented at the 1955 SAE Golden Anniversary Aeronautic Meeting in New York, set forth basic principles, general characteristics, and merits of "bypass" or "ducted-fan" engines. This type of engine appears promising as a powerplant for high-subsonic transport planes.

The paper is published in full in the 1956 SAE Transactions.

Previous to his current position as director of the Garfield Thomas Water Tunnel at the Pennsylvania State University, George F. Wislicenus was chairman of the mechanical engineering department at Johns Hopkins University, from 1948 to 1954. He was assistant chief engineer of design and research, Aircraft-Engine Division of the Packard Motor Car Co., from 1945 to 1948; and research engineer with the Worthington Pump and Machinery Corp. from 1935 to 1945.

He graduated from the State School of Mechanical Engineering in Wurzburg, Germany, and received an M.S. and Ph.D. from the California Institute of Technology. He is a member of the National Advisory Committee for Aeronautics, the Submarine Panel of the National Research Council, ASME, Institute of Aeronautical Sciences, American Association for the Advancement of Science, Sigma Xi, Pi Tau Sigma, and the American Society of Engineering Education. He is the author of, "Fluid Mechanics of Turbomachinery," 1947; "Marks' Mechanical Engineers Handbook," "Centrifugal Pump," 1951, and numerous classified reports.

The Manly Medal will be presented on behalf of SAE by Kenneth Campbell, member of the Manly Board of Award and Manager of the Research Division, Curtiss-Wright Corp., at a luncheon in Los Angeles' Hotel Statler, Oct. 4, 1956.

1956 Buckendale Lecture . . .

. . . will be presented by Michell in November at New York.

WILLIAM P. MICHELL, chief development engineer, Toledo Division, Dana Corp., has been selected to give the 1956 L. Ray Buckendale Lecture. He will present it on November 20, at the Hotel New Yorker in New York City, at a Junior and Student Meeting, sponsored by the Metropolitan Section.

In his lecture, "New Drive Lines for New Engines," Michell will discuss the selection of transmissions for trucks, with particular emphasis on how they affect the performance of the vehicle. He will also appraise, briefly, the automatic transmission for truck use. He foresees early progress in this direction for short haul, city, and off-highway units, where shifting and clutch problems are most acute, but expects that it will be some time before they are adopted for highway freight vehicles.

William P. Michell

The Buckendale Lectures are presented annually in honor of the late L. Ray Buckendale, SAE president for 1946 and vice-president in charge of engineering, Timken-Detroit Axle Co.

You'll Be Interested to Know—

SAE Council has nominated **Arthur E. Smith**, Pratt & Whitney Aircraft, Division of United Aircraft Corp., and **Robert F. Kohr**, Ford Motor Co., to be CRC directors for a 2-year term starting Jan. 1, 1957. They also renominated **L. L. Bower**, Waukesha Motor Co., to serve for another 2 years. Other SAE members on the CRC Board, who still have 1 year to serve, are **E. N. Cole**, General Motors Corp., **F. W. Fink**, Ryan Aeronautical Co., **G. J. Huebner, Jr.**, Chrysler Corp., and **Dr. Arthur Nutt**, Lycoming Division, Avco Mfg. Corp.

★ ★

Vice-president **J. T. Dyment** has appointed **R. H. Whempner**, Minneapolis-Honeywell Regulator Co., a member of the Air Transport Activity for the remainder of 1956.

SAE National

Fuels and Lubricants Meeting

The Mayo
Tulsa, Oklahoma
November 8-9, 1956

General Chairman:
W. F. Ford,
Continental Oil Co.

Thursday, November 8

Radioactive Tracer Measurements of Engine Bearing Wear

Effect of Lube Oil on Engine Octane Requirements

Starting and Warm-Up in New Automobiles

Factors Affecting Engine Oil Consumption

Vapor Lock Tendencies

Thursday Evening—Dinner—Crystal Ballroom

Friday, November 9

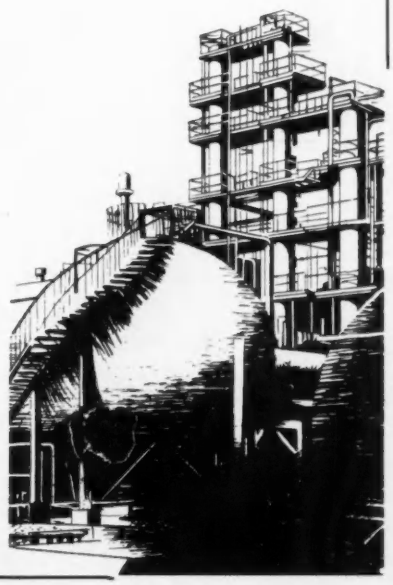
Octane Requirements of Cars at High Altitudes

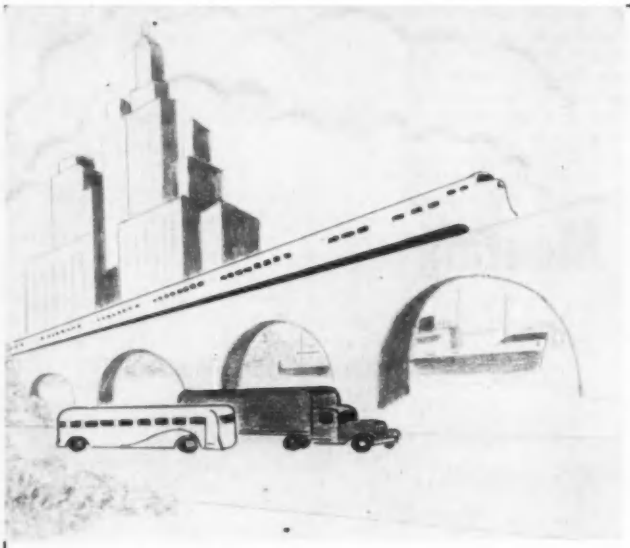
Surface Ignition in Spark Ignition Engines

New Developments in Gear Lubricants

Gear Lubricants in Military Equipment

Understanding Antiknock Action





SAE National Diesel Engine Meeting

The Drake

Chicago, Illinois

November 1-2, 1956

General Chairman: **L. F. SHOEMAKER**, Buda Division, Allis-Chalmers Mfg. Co.

Laboratory Techniques for Simulating Service Conditions

European High Speed Two Cycle Diesel Engines

Effects of Stroke and Bore on Diesel Engines

Sulfur, Snorkel, Submarines—and Sludge

Diesel Engine Exhaust Odor

Dinner: November 1 **The Drake, Gold Coast Room**

"Effects of Nuclear Power on the Diesel Engine"
by Rear Admiral A. G. Mumma USN

SECTIONS

OCTOBER 1956

Section Shorts

President Delaney was featured as guest speaker by **Twin City Section** at its Sept. 13 meeting. He spoke on "Designing an Automobile." Norman G. Shidle, SAE Journal Editor, was "coffee speaker." His topic: "Engineers We Have Met."

Mid-Continent Section heard Marvin Whitlock, vice-president, operations planning, American Airlines, speak at its Fall Aircraft meeting on Sept. 7. Whitlock described the "Turbo-Prop and Jet Operations Planning" to the members.

South Texas Group met at the Manor House in San Antonio on Sept. 24. "Development of Caterpillar Track Type Tractors" was the paper presented. Speakers for the meeting were B. D. Holt, vice-president in charge of service and parts, and Jack W. Richardson, service manager, both of William K. Holt Machinery Co.

Papers included a description of the use of new track type tractor in the construction of highways. A movie on the development of track type tractors and a film strip of the design, development, and use of the new D-9 Caterpillar tractor were shown.

Atlanta Section met at the General Motors Training Center on Sept. 10. D. R. Diggs, supervisor of the engine test group at the Petroleum Laboratory of E. I. du Pont de Nemours & Co., Inc., spoke to the group on "The Fuel Requirements of Tomorrows Engines." J. A. Ewing, also with du Pont, presented "The Single-Cylinder Demonstration Engine." Different fuels were used to show the importance of anti-knock quality and fuel type on knock and preignition.

Williamsport Group held its annual buffet meeting on Sept. 10 with some really entertaining film fare in color. Dudley King and Horace Epler gave movies and slides which were taken during their Alaskan air safari this summer.

Field Editors—1956-1957

ALBERTA GROUP
Edward T. Curlette

ATLANTA
James A. Chappelka

BALTIMORE
Dale E. Woomert

CANADIAN
Frank G. King

CENTRAL ILLINOIS
T. W. Head

CHICAGO
Ivan R. Dawson

CINCINNATI
Arthur R. Ehrnschwender

CLEVELAND
W. B. Fiske

DAYTON
Robert J. Schweller

DETROIT
George J. Gaudaen

INDIANA
Roger W. Pocock

KANSAS CITY
Carroll Abrams

METROPOLITAN
H. H. Wakeland
Randolph P. Dominic

MID-CONTINENT
Leonard W. Okon

MID-MICHIGAN
David Hadden

MOHAWK-HUDSON
Charles F. Hastie

MONTREAL
Alban A. Larkin

NEW ENGLAND
George T. Brown

NORTHWEST
Burnette H. Murray

PHILADELPHIA
Edward V. Henc

PITTSBURGH
H. J. Grance, Jr.
K. R. Schaper

SAN DIEGO
Robert E. Day

SO. NEW ENGLAND
Robert H. Gilpin

continued on next page

James D. Bradley (left), B-section SAE chairman at S. M. U. thanks Dean Engle (center right), after the meeting. Looking on are Joe W. James, ASME chairman at S. M. U. (center left), and Marvin Metcalf, A-section SAE chairman at S. M. U. (right).

Field Editors—Continued

SO. TEXAS GROUP
Norvel Killion

SPOKANE-INTERMOUNTAIN
Ernest J. Eldenburg

ST. LOUIS
Frank H. Myers, Jr.

SYRACUSE
Donald J. Ritchie

TEXAS
R. H. Williams

TEXAS GULF COAST
Leon Blagg

TWIN CITY
Albin L. Lee

VIRGINIA
F. M. Hutcheson

WASHINGTON
Loris N. Mouser

WESTERN MICHIGAN
Edsell M. Eady

WICHITA
Kenneth W. Rix

WILLIAMSPORT
Bernard L. Sharon

Section Meetings . . .

ALBERTA GROUP
October 15 . . . Al San Club. Cocktails 6:15 p.m. Dinner 7:15 p.m.

ATLANTA
November 4 . . . T & M Meeting.

BRITISH COLUMBIA
October 15 . . . **Max J. Tauschek,** chief engineer, Valve Division, Thompson Products. — "Valves and Tappets."

CANADIAN
October 18 . . . St. Catharines Meeting.—**Arthur F. Underwood,** director, Research Staff of Mechanical Development Department, General Motors Corp., Detroit.—"The Free Piston Engine Project." Dinner 7:00 p.m. Meeting 8:00 p.m.

CENTRAL ILLINOIS
October 22 . . . Elks Club. Springfield, Ill. Dinner 6:30 p.m. Meeting 7:45 p.m.

CLEVELAND
October 15 . . . The American Steel & Wire tour.
November 12 . . . Diesel Activity.

DAYTON
October 23 . . . **1956 SAE President G. A. Delaney.**—"Designing An Automobile." Dinner 6:30 p.m. Meeting 7:30 p.m. Biltmore Hotel. Junior Ballroom.

DETROIT
October 22 . . . Junior Activity Meeting—Three Speakers: **J. M. Chandler,** Ford Motor Co., **J. R. David,** Pure Oil Products Co. and **G. W. Roberts,** Pontiac Motor Division, GMC.—"Fuel Economy Can Be Improved If. . . ." Moderator: **D. J. Schwendner,** Ford Motor Co. Rackham Educational Memorial. Meeting 8:00 p.m.
October 29 . . . **R. F. McLean,** GMC.—"Bodies for Future Automobiles." Rackham Educational Memorial. Dinner 6:30 p.m. Meeting 8:00 p.m.

INDIANA
October 18 . . . **G. R. Beardsley,** product design engineer, Motor Truck Division, International Harvester Co., Fort Wayne, Ind. —"International Harvester's Approach to the V-8 Engine Program." Indianapolis Naval Armory Mess. Social Hour: 6:30 p.m. Dinner 7:00 p.m. Meeting 8:00 p.m.

KANSAS CITY
October 25 . . . **C. G. A. Rosen,** consulting engineer, Caterpillar Tractor Co., Peoria, Ill. Roselli's Restaurant. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Features: Social Hour at 6:30 p.m.

METROPOLITAN
October 18 . . . Aeronautics Activity Meeting: **Jonathan E. Boretz,** senior project engineer, Stratos Division, Fairchild Engine & Airplane Corp.—"High Speed Turbo-Pumps." Stevens Institute of Technology, Room 201, Kidde Building, Hoboken, N. J. Meeting 7:45 p.m.

MILWAUKEE
November 2 . . . **R. W. Klecker,** Nuclear Power Department, Allis-Chalmers Manufacturing Co., Milwaukee.—"The Problems of Generating Nuclear Power." Milwaukee Athletic Club. Social Hour 6:00 p.m. Dinner 6:30 p.m. Meeting 8:00 p.m. Special Features: There will be an after-meeting social hour with refreshments.

MONTREAL
October 15 . . . Mount Royal Hotel.

NORTHWEST
October 12 . . . **Max J. Tauschek,** chief engineer, Thompson Products, Inc., Valve Division, Cleveland.—"Basic Factors Affecting Engine Valves." Stewart Hotel. Dinner 6:30 p.m. Meeting 7:30 p.m.

PITTSBURGH
October 23 . . . **Carl S. Ryan,** chief automotive technologist, Eastern Region, E. I. duPont de Nemours & Co., Inc., Petroleum Chemicals Division, 1270 Avenue of the Americas, New York, N. Y. —"What's New From Detroit." Webster Hall, Mellon Institute. Dinner 6:00 p.m. Meeting 8:00 p.m.

SOUTHERN CALIFORNIA
October 15 . . . **George M. Galster,** service manager, Champion Spark Plug Co.,—"Engine Operation Seen Thru a Spark Plug." Rodger Young Auditorium. Dinner 6:30 p.m. Meeting 8:00 p.m.

SOUTH TEXAS GROUP
October 22 . . . **Richard B. Sneed,** technical representative, Ethyl Corporation, Detroit.—"Fuel Requirements of Future Automobiles." Manor House, San Antonio, Texas. Dinner 7:00 p.m. Meeting 8:00 p.m.

SYRACUSE
November 12 . . . Joint Meeting with Technology Club of Syracuse. Speaker from General Motors Technical Center. Syracuse Museum of Fine Arts. Dinner 6:30 p.m. Meeting 8:00 p.m.

TEXAS
October 12 . . . Truck & Bus Meeting. Technical Chairman: **Tom Collins,** president Collins Equipment Co., Dallas, Texas. Dinner 7:30 p.m. Meeting 8:30 p.m.

VIRGINIA
October 22 . . . William Byrd Hotel.

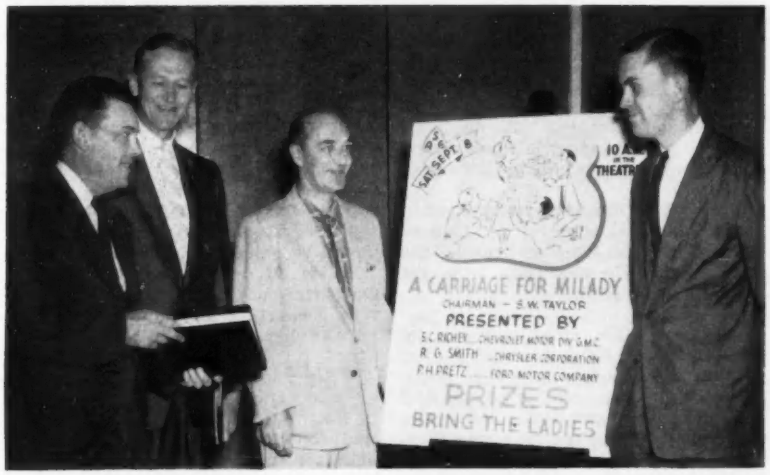
WASHINGTON
October 16 . . . Field Trip to PAX River. Dinner 6 p.m.

WILLIAMSPORT GROUP
November 5 . . . Moose Auditorium.

SAE Detroit Section's White Sulphur Meeting

Leaders of the meeting were Section Chairman C. C. Dybvig (center); Chairman of the Section's Greenbrier Meeting Oliver Kelley (right); and Technical Sessions Chairman Glenn R. Fitzgerald (left).

Detroit Section hosted over 400 at its Summer Meeting at Greenbrier in White Sulphur Springs Sept. 7-9. Featured were technical sessions on material for the car of the future and the influence of feminine wants on automobiles.


A CARRIAGE FOR MILADY
CHAIRMAN – S.W. TAYLOR
PRESENTED BY
S.C. RICHEY ... CHEVROLET MOTOR DIV. G.M.C.
R. G. SMITH ... CHRYSLER CORPORATION
P.H. PRETZ ... FORD MOTOR COMPANY
PRIZES
BRING THE LADIES

"A Carriage for Milady" session drew chuckles as well as discussion with the female contingent out in full force. Responsible for this session were: S. W. Taylor (center left), session chairman; and session speakers S. C. Richey (left); P. H. Pretz (center right); and and R. G. Smith (right).

Car materials session chairman and speakers comment on the cars of the future. Left to right are: D. N. Frey, M. J. Kittler, session chairman, A. L. Boegehold, and M. F. Garwood.

Session included, in general terms, the requirements of materials to be used in conventional gasoline piston engines, gas turbines, diesel engines, and the free piston engine as they are developed in the future.

Also discussed were the trends in the use of light materials for automobile body and chassis, and a review of the possible effects of improved processing techniques such as shell molding selection of materials.

About SAE Members

Wirth Heth Sawyer Boehm

Ricks West Lynas Fill

EMIL O. WIRTH, on the management staff of the vice-president and group executive of Bendix Products Division, Bendix Aviation Corp., is presently assigned as manufacturing manager of the Division's airframe components, Aircraft Wheel and Brake Plant.

Wirth currently is a member of the SAE Production Activity Committee. He has been Meetings vice-chairman of the committee, and has been active in the last several years in the development of Production Meeting programs and Production Forums.

SHERMAN C. HETH is now chief engineer, advanced engineering department, McCormick Works, International Harvester Co. He had been chief engineer, grain machinery, Main Works, J. I. Case Co. Heth is the 1956–1957 vice-president of SAE Tractor and Farm Machinery Activity Committee.

WILLIAM M. CADE has been made chief engineer at the Memphis plant of International Harvester Co. Formerly, he was chief engineer in the advanced engineering department at McCormick Works.

R. TOM SAWYER has been named a consultant on engineering and development problems at ALCO Products, Inc. He was the company's research manager. In addition to his ALCO duties, he will act as consultant to the staff of the Experimental Towing Tank at Stevens Institute of Technology.

Sawyer joined ALCO's predecessor the American Locomotive Co. in 1930 as a sales engineer. In 1941 he was made a diesel equipment engineer for ALCO. He was appointed manager of the research department in 1947, and was named manager of research in 1953.

He is the author of "Diesel Locomotives," "The Modern Gas Turbine," "Gas Turbine Construction," and the co-author of "Applied Atomic Power."

A. BRUCE BOEHM has been elected to a newly created post of executive vice-president of Enjay Co., Inc.

Boehm has been a vice-president of Enjay and sales manager of the firm's Butyl Rubber Division. He has been associated with the Enjay Co. since 1947, when he was appointed sales manager of its Paramins Division.

BERNARD E. RICKS, 1956–1957 SAE Western Michigan Section chairman, has been named plant manager of of the new Van Dyke Road plant of Thompson Products, Inc. He has been manager of the Fruitport Works plant at Thompson.

Ricks joined the company in 1940 as a draftsman. He was made assistant chief engineer in 1943, and was appointed manager of the Fruitport plant in 1953.

WILLIAM WEST is now consultant for several building programs being undertaken by Thompson. Formerly he was head of the industrial engineering department of the Michigan Division of Thompson.

ROBERT M. LYNAS, assistant divisional industrial engineer at Thompson, will succeed West as head of the department. He has been with the company since 1950.

LYNN A. FILL, chief engineer for Motor Products Corp. is retiring after serving in that capacity for 40 years. Currently, he is a member of the SAE Body Activity Committee. He is also a past-president of the American Society of Body Engineers, and has served on the Credentials Committee of the Engineering Society of Detroit.

R. M. TULLOS has been made general service manager of Reo Motors, Inc. He was service operations manager in charge of all retail and distributor service facilities at Reo.

M. C. CROCKETT has been made automotive industry sales manager for Kaiser Aluminum & Chemical Sales, Inc. He was Detroit district manager for the company. Crockett joined Kaiser Aluminum in 1947 as a salesman in Los Angeles. Prior to becoming manager of the Detroit District in 1953, he served as assistant district manager in New York.

FREDERICK J. GARBARINO, formerly chief engineer of New Departure Division, General Motors Corp., has been named director of quality control for the division. He joined New Departure in 1935, and was promoted to chief engineer in 1951.

SETH H. STONER will succeed Garbarino as chief engineer for the New Departure Division. Previously he was divisional general works manager.

Stoner started in General Motors as a junior engineer with GM Research in Detroit. He joined New Departure in 1935, and was made general works manager in 1951.

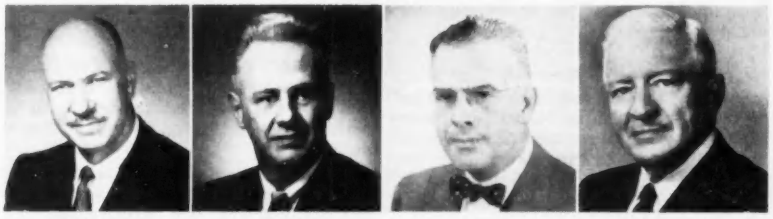
GEORGE J. HANNES, assistant technical manager of the L.O.F. Glass Fibers Co. plant in Parkersburg, W. Va., has been promoted to manager of the Automotive Research & Development Division of the company.

Before joining L.O.F. Glass Fibers, Hannes was a research analyst in the distribution research department of Libbey-Owens-Ford Co.

FREDERICK W. WINYARD is now a production engineer at American Shipbuilding Co., Cleveland, Ohio. Prior to joining American Shipbuilding, he was manager of Brooke Dockyard & Engineering Works, Kuching, Sarawak, British Borneo.

Vanderberg | Gray | White | Sherman

Strunk | Witzke | Mogg | Mac Farlane



Williamson | Munroe | Magill | Rockwell

KENITH G. STRUNK, previously president of the engineering consultant firm of Processes Research, Inc., has been appointed administrative director of engineering, Breeze Corp., Inc., Union, N. J.

Strunk will be in charge of Breeze's entire engineering department, including research, development, drafting, and product engineering.

FRED WITZKE has been appointed manager of sales engineering, Cleveland Instrument Co. Inc. Prior to joining Cleveland Instrument, he was a product supervisor for gaging equipment with Brush Electronics Co.

WILLIAM R. MOGG has been named special products sales manager of the Cleveland Graphite Bronze Co., a division of Clevite Corp.

For the past 11 years Mogg has been a sales representative in the Chicago office of the company.

Mogg was 1954–1955 SAE Chicago Section vice-chairman of the Parts and Accessories Committee.

WAYNE H. MAC FARLANE, vice-president and director of engineering of Minneapolis-Moline Co., has been named to a new position as vice-president—administration.

Mac Farlane began work in 1935 at the firm's Minneapolis tractor plant. In 1946, following his return from the U. S. Army, he was named manager of materials and methods. He became manager of the firm's Louisville plant in 1952. He was elected vice-president and director of engineering two years later.

WILLIAM E. SWENSON, assistant director of engineering succeeds Mac Farlane as director of engineering. He joined the company in 1926 as a tracer. In 1943 he was made a design engineer, and in 1944 was promoted to assistant chief engineer.

Swenson became design correlator for the manufacturing and engineering divisions of the company in 1954. The following year he was appointed assistant director of engineering.

DR. MERRITT ALVIN WILLIAMSON, has been named dean of the College of Engineering and Architecture at Pennsylvania State University. He was manager, Research Division, Burroughs Corp., and also a special lecturer on research administration at the University of Pennsylvania.

Williamson began in the field of engineering in 1937 at Scovill Mfg. Co., and worked there as a metallurgist until 1942. For the next two years he served as a metallurgist with the Remington Arms Co., and from 1944 to 1946 he served on active duty as an ensign and later a lieutenant with the U. S. Navy.

In 1946 he was named director of technical research for Solar Aircraft Co. From 1948 until 1952, when he accepted his present position with Burroughs, he was associate director of development, research department of the Pullman Standard Car Manufacturing Co.

G. C. VANDERBERG has been named engineering consultant to the vice-president in charge of the Axle Division, Clark Equipment Co. He joined Clark in 1919, and had been chief engineer of the division since 1937.

L. M. GRAY succeeds Vanderberg as chief engineer of the Axle Division. Previously, he was assistant to the chief engineer. Gray has been with the company since 1925.

WILLIAM E. WHITE has been made development engineer of the Axle Division. He had been product engineer in charge of brake specification and design for all Clark divisions. Before joining Clark in 1953, White was with Bendix Aviation Corp., for 13 years.

WILLIAM F. SHERMAN has been appointed exposition director for the revived National Automobile Show which will be held this year at the new Coliseum in New York City, Dec. 8–16. The last National Automobile Show in New York was held in 1940. Sherman is also manager of AMA's engineering and technical department.

MARSHALL E. MUNROE, JR., director of procurement for Massey-Harris Ferguson Inc. since 1954, has been appointed a vice-president of the company.

Prior to the merger of the Massey-Harris and Ferguson companies in 1953, Munroe served with Harry Ferguson, Inc. from 1939 in both sales and purchasing capacities.

FULTON R. MAGILL, standards engineer at Rockwell Mfg. Co., has been named manager of a newly created central standards department at the company's headquarters in Pittsburgh.

He joined Rockwell's Delta Power Tool Division as an administration and standards engineer in 1953 after 12 years as forecast engineer and control engineer with U. S. Steel Corp. In the previous 13 years he was a partner in the Magill Forge, New Castle.

COL. WILLARD F. ROCKWELL, chairman of the board of Rockwell Mfg. Co. and Rockwell Spring & Axle Co., has been knighted by the Italian government in the order "Al Merito Della Repubblica." The honor, which is usually reserved for Italian citizens, was conferred for "outstanding contributions to Italy's reconstruction and economic recovery."

Hottenroth

Self

Rill

Johnson

FRED W. HOTTENROTH has been named vice-president in charge of technical sales, a newly created position at Hupp Corp., Cleveland.

Prior to joining Hupp, Hottenroth served as sales manager of Clifford Mfg. Co., a division of Standard-Thomson Corp. For 15 years he was with General Electric Co., and later became chief engineer of Penn Controls, Inc., Goshen, Ind.

KENNETH W. SELF has been elected vice-president of Freightliner Corp., Portland, Ore. **THOMAS D. TAYLOR,** president of the firm, announced the election following the corporation's annual meeting.

Self began in industry in 1935 as an apprentice mechanic at Novelty Carriage Works, Spokane. He joined Freightliner Corp.'s parent company, Consolidated Freightways, as a maintenance mechanic in 1940, and has successively been assistant shop foreman, maintenance superintendent, service floor foreman, shop superintendent, and production manager.

A. L. THOMPSON has been named sales manager of Eclipse Machine Division, Bendix Aviation Corp. He has served as a resident engineer in plants of customers.

R. K. GORNALL has been appointed assistant sales manager for Stromberg carburetors at Eclipse. He had been Stromberg resident engineer at the Studebaker plant in South Bend, Ind.

C. L. MELLOR, JR. has been made sales manager for Bendix starter drives at Eclipse. He was a sales engineer with the division.

MURRAY K. SIMKINS, managing editor, *Commercial Car Journal,* Chilton Co., has been made eastern editor of two new publications that Chilton has recently purchased—*Gas* and *Butane and Propane News.*

Simkins was 1955–1956 membership vice-chairman for the SAE Transportation and Maintenance Activity. He also served on the 1955–1956 SAE Truck and Bus Committee.

RAY C. HERD has been made machine shop manager, Piston Service Inc., Seattle, Wash. He had been retail service manager, GMC Truck & Coach Division, General Motors Corp.

CARROLL N. RILL has been appointed director of research, Phoenix Oil Co., Cleveland. Since 1947 Rill has been vice-president and director of research for the Franklin Oil & Gas Co., Bedford, Ohio.

Prior to that time, he was chemical director of Nox-Rust Chemical Corp. During World War II he was a member of the War Advisory Board for Rust Preventives. Rill also was engaged for 11 years in the formulation of lubricants and specialties for Socony Mobil Oil Co., Inc.

THOMAS W. JOHNSON has been appointed group executive in charge of both the recently formed Vacuum Equipment Division and the Kinney Mfg. Division of the New York Air Brake Co. Prior to his appointment, Johnson was director of engineering for the company.

Johnson joined New York Air Brake in 1953 as assistant to the company's executive engineering consultant. Before that, he was with the Eclipse Pioneer Division of Bendix Aviation Corp. for six years as a senior research engineer.

NORMAN LEVINE, formerly process engineer, jet engine plant, Chrysler Corp., has been made supervisor of manufacturing engineering at the Detroit plant of the Radio Corp. of America.

Levine will be responsible for fabrication and subassembly, cost estimating methods, time study, plant layout, process quality control, and gaging methods.

J. E. RHEIM has been elected president and general manager of Rohr Aircraft Corp., Chula Vista, Calif. He had been executive vice-president of the company.

FRED H. ROHR was elected chairman of the board and chief executive officer at Rohr Aircraft. Rohr previously was president of the company.

DANIEL B. WEINSTEIN has been appointed senior engineer on nuclear core engineering projects at the Bettis plant, which Westinghouse Electric Corp. operates for the Atomic Energy Commission. He was a project engineer at the Aviation Gas Turbine Division of Westinghouse Electric Corp.

DON W. GERI is now a research engineer with North American Aircraft, Inc., Downey, Calif.

GEORGE W. HALDEMAN has been named director of safety, National Airlines, Inc., Miami, Florida. He had been special assistant to the director, Office of Aviation Safety, Civil Aeronautics Administration, Washington, D. C. Prior to that he had been chief of the Aircraft Division at CAA.

Haldeman had been with the Civil Aeronautics Administration for 20 years, and has had 38 years of flying experience.

In his new position he will have charge of research and development planning for turbine powered transports.

ROBERT W. FLEMING has been made senior engineer, Atomic Power Division, Westinghouse Electric Corp. Fleming was assistant professor of mechanical engineering at the University of Wisconsin.

ROBERT T. HERDEGEN, JR., production manager, Dominion Forge Ltd., Ontario, Canada, has been elected a director of the Drop Forging Association.

H. G. RAHN, who was manager of the commercial tire department at Dominion Rubber Co. Ltd., is now sales manager with Pacific G. M. C. Ltd.

RONALD W. CAMPBELL is now a development engineer with Hancock Mfg. Co., Jackson, Mich. He was an engineer with Hayes Industries of Jackson.

LESTER W. TREES, service manager of Scintilla Division of Bendix Aviation Corp., was awarded a certificate honoring his 30th anniversary with the company.

Trees joined Scintilla in 1926 after having served as an ignition specialist with the Air Force. In 1939, he was appointed to his present position of service manager of the division.

JOHN G. HAIG is now a production engineer with New Process Gear Corp., Syracuse. He was parts and service manager of Hoffman Motor Car Co. of Chicago, Inc.

BURNHAM ADAMS has been made manager of the West Coast branch of Caldwell Wright Division, Curtiss-Wright Co. He had been sales manager of the Aero-Pneumatics Division of Pacific Airmotive Corp.

JAMES R. LEE is now design engineer with Vanadium Corp. of America. He had been fleet superintendent of maintenance for Norwalk Truck Line Co., Norwalk, Ohio.

DOUGLAS W. HAMM is now director of product engineering for Muskegon Piston Ring Co. **HAROLD G. VAUGHAN**, president of the company, announced that Hamm will supervise product engineering in all divisions of the firm.

Hamm has been chief engineer at Muskegon for the past three years. He joined the company in 1939.

ALLAN E. SWARTZ has been made chief product engineer, Muskegon Division, Muskegon Piston Ring Co. Previously, he was a test engineer with the company. He joined Muskegon Piston Ring in 1952 as a project engineer.

J. H. PICKUP is now a territory manager of the San Francisco area for Champion Spark Plug Co. Formerly, he was assistant territory manager for the Los Angeles area.

Pickup is 1956–1957 chairman of SAE Northern California Section Membership Committee.

R. M. WHEELER has been made executive assistant of Seneca Falls Machine Co., Seneca Falls, N. Y. Wheeler had been chief engineer with the company.

N. M. PAREKH is now an engineer with National Carbon Co., India, Ltd., of Union Carbide International Co. He was superintendent of planning for Tata Locomotive & Engineering Co., Ltd., Telco Works, Jamshedpur, India.

GEORGE E. ROWBOTHAM has been made engineering manager, Hartford Special Machinery Co. He was formerly chief draftsman, Chandler-Evans Division, Niles-Bement-Pond Co.

THOMAS B. RHINES, formerly assistant chief engineer, Hamilton Standard Division, United Aircraft Corp., has been appointed to the operating committee of Hamilton Standard.

Rhines began his career as an aeronautical engineer in United Aircraft's Research Division in 1932. He joined Hamilton Standard in 1939, and held posts of assistant engineer, chief production engineer, and chief development engineer before being named assistant chief engineer in 1951.

Discuss Studebaker-Packard Plans

HAROLD E. CHURCHILL (left), new president of Studebaker-Packard Corp., confers in South Bend, Ind., with **ROY T. HURLEY**, chairman and president of Curtiss-Wright Corp., on 1957 and 1958 car development plans. This meeting followed the agreement signed Aug. 6 between the two companies bringing $35,000,000 in new financial resources to Studebaker-Packard.

JAMES L. QUINNELLY is now a student officer at Command & General Staff College, U. S. Army, Ft. Leavenworth, Kan. He had been chief, technical branch, Ordnance Division, Headquarters, U. S. Army, Europe.

MARCUS F. WARMUTH is now administrative engineer with Airborne Accessories Corp. He previously was a staff engineer and assistant to the vice-president in charge of sales at Air Associates, Inc.

WILLIAM F. SAEFKOW has been appointed manager of the Detroit district office, Valve Division of Thompson Products, Inc. He was the division's Detroit district sales manager.

RALPH A. MINKE, formerly the division's Detroit district engineering manager, has been made assistant district manager.

FRANK R. HOLLIDAY is now an assistant managing engineer of the Engineering Division of the Chrysler Corp. He is in charge of all stress analysis activities and also of laboratory fatigue testing in connection with the stress analysis function and the coordination of all work in the Life Test Laboratory of the Mechanical Laboratories.

FRANK J. WEBER, formerly a project engineer at Chrysler's Brake Laboratory, is now an assistant managing engineer specializing in brakes. He is responsible for development work on service and parking brakes and their operating mechanisms for both passenger cars and trucks. He will also direct the activities of a recently established brake development group at the Proving Grounds.

CLARENCE P. SCHNEIDER has been appointed general manager, Wabash Division, Raybestos-Manhattan, Inc. He was factory manager at the Wabash Division plant.

Schneider started with the Manhattan Rubber Division, Passaic, N. J. in 1929 in the engineering department. In 1936 he was transferred to the manufacturing department as production engineer and later was named assistant manager of friction materials. In 1951 he was transferred to the newly built Wabash Division plant as factory manager.

Hamm | Swartz | Pickup | Wheeler

Kartveli

Bowman

O'Donnell

ALEXANDER KARTVELI, chief engineer and a vice-president and director of Republic Aviation Corp., has been appointed vice-president in charge of research and development for the company.

RICHARD G. BOWMAN, formerly assistant chief engineer for production at Republic Aviation, has been promoted to chief engineer in charge of production and experimental engineering.

DR. WILLIAM J. O'DONNELL has been made chief engineer in charge of aircraft and missile development at Republic Aviation. He previously was an assistant chief engineer in charge of development and experimental engineering.

NORMAN G. SHIDLE, editor, SAE Journal, has been elected a Trustee Member of the Engineering Index, Inc.

J. W. LENDVED, director of engineering for the Construction Machinery Division, Chain Belt Co., will also serve as director of product development for that division.

RALPH F. PEO, president of Houdaille Industries, Inc., has announced the purchase of Wales-Strippit Corp., North Tonawanda, N. Y. by Houdaille.

JOHN T. McCOY, formerly divisional research and development supervisor of Tidewater Oil Co., has been named to the post of manufacturing department coordinator, representing the company's Delaware Flying A Refinery in the divisional offices at New York City.

Four SAE members have been appointed to the 22-member Advisory Committee for the new Transportation Center at Northwestern University. They are: **ROBERT E. GROSS,** president, Lockheed Aircraft Corp.; **PAUL G. HOFFMAN,** chairman, Fund for the Republic; **ROY C. INGERSOLL,** chairman, Borg-Warner Corp; **CYRUS R. OSBORN,** vice-president, General Motors Corp.

Established with financial support from every element of the transportation industry, the center will engage in research, education, and consulting services in economic, commerce, engineering, and regulation areas.

Directed by Franklin M. Kreml, it will operate within the framework of Northwestern. Kreml is on leave from Northwestern's Traffic Institute, which he founded.

HARRY F. VICKERS, president of the Sperry Rand Corp., has been awarded the ASME medal of the American Society of Mechanical Engineers. He was cited for his "pioneering in industrial oil hydraulics and for notable accomplishments in business leadership."

CARL O. TONGBERG has been elected a vice-president and a director of Carter Oil Co. Tongberg, formerly a vice-president and director of Esso Research & Engineering Co., will be in charge of production research activities conducted by Carter on behalf of producting affiliates of Standard Oil Co.

J. G. PEARSON has announced the opening of Pearson Motors, Guelph, Ontario, Canada, an automotive engineering company which he owns.

Pearson had been service engineer with Morris Motors of Canada Ltd. before opening his own concern.

MURRAY BERKOW, director of sales engineering, Republic Aviation Corp., has been made assistant sales manager in charge of weapons systems for the company.

He will be responsible for the operations of field service and the Weapons Systems Requirements Division. Berkow joined Republic in 1941 as a development engineer.

D. C. GIBBARD is now sales manager of the Sealed Power Corp. of Canada, Ltd., Ontario, Canada. He was manager, Replacement Division, Thompson Products, Ltd., Ontario, Canada. Gibbard has been with Thompson for the past 18 years.

CARL P. MULLEN has been appointed to the board of management for the Gates Rubber Co., Denver, Colo.

Mullen joined Gates as a development engineer in the technical department. For several years he did compounding and product development work in Molded Rubber Goods, Belts, and Hose divisions.

Later he became manager of the Hose Development Division, then manager of Hose and Belt Development and Research. He was then promoted as an assistant to the vice-president in charge of technical development and research. In January, 1956, he was chosen to head the industrial engineering department.

Mullen is vice-chairman of SAE-ASTM Technical Committee "A" on Automotive Rubber, and chairman of the Ordnance Advisory Committee on Hose Products.

M. H. ALLDREDGE, JR., is now sales representative of the Bingham Stamping Division of the Bingham-Herbrand Corp. Previously, he was sales manager of the Michigan Division of Thompson Products, Inc. Alldredge had been with Thompson Products since 1923.

M. J. HOKE has been named president and general manager of the Ohio Crankshaft Co. Formerly he was vice-president and general manager of the Camshaft and Crankshaft Division.

Before joining Ohio Crankshaft in 1945 as a development engineer, he had wide experience in the engineering field with Consolidated Aircraft, the Electromotive Division of General Motors, and with the Cincinnati Milling Machine Co.

McKINLEY W. THOMPSON, JR. is now an automotive stylist at the Ford Motor Co.'s styling center in Dearborn, Mich. Formerly he was associate body designer at Panelcraft Metal Shaping, Lynwood, Calif.

Gibbard

Mullen

Alldredge

Hoke

JOHN H. DURANT has been appointed director of public relations, National Research Corp. He has been with the company since 1943.

Durant has served as a research assistant in metallurgy, an engineer in the Equipment Division, and as sales engineer. His most recent assignment prior to this appointment was as business manager of the Research Division.

DR. C. L. FLEMING, JR. has been named deputy coordinator, Esso Research and Engineering Co. He was director of Products Research Division of the company.

DR. J. G. McNAB will succeed Fleming as director of the Products Research Division. He had been associate director of research, Esso Laboratories, Research Division.

DR. N. V. HAKALA, formerly assistant director of Esso Laboratories, will be associate director of the Products Research Division.

WILLIAM J. BIRD, formerly vice-president in charge of sales, Plymouth Division, Chrysler Corp., has been appointed to the staff of **WILLIAM C. NEWBERG**, group vice-president.

Bird has been associated with Chrysler for more than 20 years.

In 1947 he was named vice-president of the Fargo Fleet Sales Division. In 1953 he was appointed general sales manager of Plymouth, and the following year he became Plymouth vice-president in charge of sales.

CHARLES E. BARBY is now manager of automotive sales, Fiber Glass Division, Pittsburgh Plate Glass Co.

Barby joined Pittsburgh Plate in 1939 as a salesman in the St. Louis distributing branch. He was named paint manager there in 1945, and five years later served in the same capacity at the company's Dallas distributing branch.

He was made director of sales for the Dallas unit in 1951 prior to his transfer a year later to the Fiber Glass Division in Detroit.

LEONARD B. GILBERT has been elected vice-president, central district, White Motor Co. Gilbert formerly served as a regional manager for White Motor.

WILSON D. PATTERSON was elected vice-president, Pacific Coast district, White Motor Co. He had been a regional manager for the company.

LOUIS E. DURKEE is now sales engineer with Le Roi Division, Westinghouse Air Brake Co. Formerly, he was field service representative with Power Products Corp.

RAYMOND DE GENNARO is now a research engineer with Republic Aviation Corp., Farmingdale, N. Y. He was a student at Tri-State College, Angeola, Ind.

FRANK J. HAHN is now a group project engineer, Lycoming Division, Avco Mfg. Corp. He had been assistant director—quality, Fairchild Engine Division, Fairchild Engine & Airplane Corp. Hahn was a member of the Quality Control Panel at the 1955 and 1956 Aeronautic Production Forums.

C. W. BOHMER, JR. has been named northern region sales manager by Esso Standard Oil Co. He had been merchandising sales manager for Esso Standard since May, 1955.

In his new assignment as northern region manager, he will supervise marketing divisions in ten northeastern and middle-Atlantic states, and the District of Columbia.

ROY HAEUSLER, auto safety engineer, Chrysler Corp., has been elected vice-chairman of the American Standards Association Highway Traffic Standards Board Executive Committee.

ROBERT A. MITCHELL, Motor Truck service manager for Canada, International Harvester Co. of Canada Ltd., has also been elected to the committee.

JOHN F. KUNC has completed 30 years' service with the Esso Research and Engineering Co. Kunc, who has headed the Esso Research's exploratory section in the Products Research Division since 1951, started as a messenger at the Bayway Refinery of Esso Standard Oil Co. He earned a bachelor's degree in chemistry in 1934 from Brooklyn Polytechnic Institute by attending classes at night for eight years. He held the postions of laboratory inspector, analyst, and laboratory assistant prior to being named a research chemist in 1942. He worked in the aviation fuels field from 1942 to 1944, heading the section in 1947.

J. H. CARMICHAEL, president, Capital Airlines, Inc., has been appointed 1956–1957 chairman of the Transportation and Communication Committee of the United States Chamber of Commerce.

LIGHT B. YOST, director, field operations section, General Motors Corp., was also appointed to the committee.

L. D. CRUSOE, executive vice-president, Car and Truck Divisions, Ford Motor Co., has announced the consolidation of the Continental and Lincoln Divisions of the company.

BEN D. MILLS, Ford Motor Co. vice-president and Lincoln Division general manager, will be in charge of the new organization which will be known as the Lincoln Division.

B. W. BOGAN has been appointed executive engineer, Chrysler Corp. He had been chief engineer, Dodge Division.

ROBERT L. McKINNON is now project engineer for accessories, Clinton Machine Co., Clinton, Mich. Previously, he was a designer in the air conditioning group at Douglas Aircraft Co.

LEWIS LARON GOBER is now acting chief, production engineering branch, Industrial Operations Division, Army Ballistic Missile Agency, Huntsville, Ala. He had been chief, equipment branch, Aviation Engineering Division, Directorate of Facilities Support Headquarters, U. S. Air Force.

DAVID E. DAY has been elected vice-president, Iricon Agency Ltd. Iricon is the organization established to represent the five per cent interest in the Iranian Consortium held by American Independent Oil Co., Atlantic Refining Co., Getty Oil Co., Hancock Oil Co., Richfield Oil Corp., San Jacinto Petroleum Corp., Signal Oil and Gas Co., Standard Oil Co. of Ohio, and Tidewater Oil Co.

Day is vice-president in charge of manufacturing for Richfield Oil Corp.

HOWARD HILL has been appointed sales and service representative of the Ionic Spray Division of Scientific Electric. He formerly was with the Ransburg Electro-Coating Corp.

WALTER STUBBS has been appointed assistant to the executive vice-president of Air Associates, Inc., Teterboro, N. J. He joined Air Associates as a staff engineer in the Aircraft Products Division and later was made quality control manager of the division. He then was promoted to divisional chief engineer, the position he held until this new appointment.

WALTER D. McKINLEY is now secretary-treasurer, Timely Technical Products, Inc., Whippany, N. J. He had been project engineer with Tite-Flex, Inc., Newark, N. J.

CHARLES J. CALVIN is now assistant managing dirctor, Truck-Trailer Manufacturers Association. Formerly, he was with the Washington, D. C. office of the Automobile Manufacturers Association.

ERNEST R. BREECH, chairman of the board, Ford Motor Co., has been elected chairman of Ford's new subsidiary, Aeronutronic System, Inc.

D. S. HARDER, executive vice-president in charge of Ford's manufacturing division was also elected to the Aeronutronic board.

H. M. HORNER, chairman of United Aircraft Corp., was awarded a 30-year pin by the company in recognition of his 30 years of service with United Aircraft.

FREDERICK F. FOX, previously a field engineer with Zollner Corp., Fort Wayne, Ind., is now assistant manager, engine test laboratory, Mack Trucks, Inc., Plainfield, N. J.

THOMAS J. HUTCHISON is now plant manager of the Rockwell Spring and Axle Co., Mishawaka, Ind. He had been chief engineer with Rockwell Spring and Axle.

G. W. TRICHEL has been appointed president of the Amplex Division of Chrysler Corp. He has been executive vice president and general manager of Amplex.

HERBERTH E. HEAD, supervisor of electro plating and related operations of the Automotive Body Division of Chrysler Corp., was elected second vice-president of the American Electroplaters' Society.

DR. ARTHUR W. LEWIS has been named superintendent of technology at the Delaware Flying A Refinery, Tidewater Oil Co. Lewis was head of the research laboratory at Bayonne.

THOBURN P. SANDS has been appointed section manager in the development department, Organic Chemicals Division, Monsanto Chemical Co. He was an automotive engineer in the division's research department. Sands will manage the department's petroleum chemicals and functional fluids section.

HARRY MUNDY has been named technical editor of *The Autocar*, one of England's leading automotive journals. He was chief designer, Coventry Climax Ltd., Associated Co., Diesel Engines Ltd. of Coventry, England.

MERRITT A. MIERAS has been appointed vice-president in charge of sales engineering for Dearborn Marine Engines, Inc. For the past 12 years he has been vice-president in charge of sales and engineering for Novi Equipment Co., Novi, Mich.

Mieras began his career with the Stromberg Carburetor Co. in Chicago. Later he became a sales and engineering executive with United Specialities Co., Chicago, and Industrial Wire Cloth Products, Wayne, Mich. He has been a member of SAE for 25 years.

LEONARD W. OKON, formerly director of editorial engineering for Chek-Chart Corp., has been made manager of sales technical service, Deep Rock Division, Kerr-McGee Oil Industries, Inc. His headquarters will be the sales technical service laboratory at Kermac's Cushing refinery.

T. F. SCHRAG, formerly account representative with Clark Equipment Co., is now sales engineer with Timken Detroit Axle Division, Rockwell Spring and Axle Co.

Schrag served SAE Detroit Section in 1954–1955 as assistant vice-chairman for the Truck and Bus Activity. He was 1955–1956 vice-chairman of the Section's Student Committee.

W. H. VANN has been appointed quality co-ordinator of Pontiac Motor Division, General Motors Corp. He joined Pontiac in 1926 and has been chief inspector since 1931.

ALVIN L. SPRINGER is now division service manager, Trailmobile Inc., Dallas, Texas. He was vice-president of equipment and purchasing, Ryder Truck Rental System, Jacksonville, Fla.

Obituaries

EARL V. FARRAR

Earl V. Farrar, chief engineer of the Wright Aeronautical Division of the Curtiss-Wright Corp., Wood-Ridge, died on August 11. He was 53 years old.

Farrar joined the Wright organization in 1929 and eventually held most of the top engineering posts in the engine manufacturing concern. He was appointed chief engineer in 1955.

He was born in Calvert, Kan., and received a mechanical engineering degree at Kansas State College in 1926 and a Master of Science degree at Purdue University in 1929. Kansas State awarded a "professional degree" in mechanical engineering to him in 1931. He was an instructor in descriptive geometry and engineering drawing during his graduate work. After joining Wright Aeronautical he became for a time an instructor of engine dynamics at New York University.

Farrar had been a member of the turbine subcommittee of the National Advisory Committee for Aeronautics, and a member of the Automotive Council for War Production during World War II.

He was an active member of the SAE Membership Grading Committee, a a member of the SAE Aircraft Powerplant Activity Committee in 1953–1954, and in 1954 served on the SAE Board of Governors for Metropolitan Section as vice-chairman for Aeronautics.

HARVEY D. CARBIENER

Harvey D. Carbiener, a design engineer for the Automotive Division, Excel Corp., died June 5.

He joined Excel Corp. in 1939 as a sample maker. In 1943 he was made an experimental template and model maker. Four years later he was appointed foreman of the experimental department. In 1949 he became design engineer working on sashes for new model cars. He became a member of SAE in 1954.

SIDNEY J. WILLIAMS

Sidney J. Williams, who was associated with the National Safety Council from 1918 to 1950, died on August 5. Williams was 70.

Born in Milwaukee, he studied at the University of Wisconsin and received an engineering degree in 1908. He began his career in 1907 as assistant engineer of the Utah Gas and Coke Co. From 1908–1913 he was an engineer and superintendent for R. B. Hartman Co., a construction firm. During World War I, he was engineer of the Wisconsin Industrial Commission.

Williams joined the National Safety Council as its chief engineer in 1918. From 1924 to 1943 he was director of its Public Safety Division. He became general manager of the National Safety Council in 1943. Two years later he was made assistant to the president. He was also a consultant to the Federal Safety Council, and was director of safety of the Federal Civil Works Administration during the early New Deal days.

In 1938 Williams received the grand award of $5000 of the Commercial Investment Trust Safety Foundation. In 1950, he was chosen Beecroft Memorial Lecturer of the Society of Automotive Engineers.

OSCAR C. KREIS

Oscar C. Kreis, former consulting engineer for General Motors Corp. Overseas Operation, died on July 5. Kreis, who was 78 years old, had been retired for a year. He was associated with General Motors for 22 years, serving as its engineering representative in Germany, Australia, and England. During World War II he was assistant chief engineer of Fisher Tank Division.

Kreis joined Leland Faulkner & Co. in 1900. From 1902 to 1908 he was a designing draftsman with Packard Motor Car Co., Holley Bus Co., and Burroughs Adding Machine Co. He was chief engineer at Gray Motor Co. from 1908 to 1916. From 1916 to 1932 he was chief research engineer with Continental Motors Corp. The following two years he was a constructing engineer with Studebaker Corp., a position he held until joining General Motors.

Control Pressure Loss At Supersonic Speeds

Based on paper by

RUDOLPH HERMANN
University of Minnesota

A variable engine inlet air diffuser is the most efficient device used to reduce the velocity and increase the static pressure of a fluid passing through a system. On aircraft they are required at flight speeds of Mach 1.4 and higher in order to capture engine inlet air efficiently.

The inlet diffuser must be variable to give maximum pressure recovery at supersonic speeds. Deceleration to subsonic velocity of supersonic airstream entering the inlet is done most efficiently by a sequence of shocks. The variable inlet diffuser is needed to produce a series of oblique shocks. These can be produced by one of two types of diffusers—a cone with a variable position spike or a wedge with varying angle. These variations can result in a change in shock wave position which regulates the airflow rate into the inlet so that maximum pressure recovery exists and there are no instabilities in the entering airflow.

(Paper "Engine Inlet Air Diffuser Controls for Supersonic Aircraft" was presented at SAE National Aeronautic Meeting, New York, April 10, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Good Plant Layout Cuts Production Cost

Based on report by

R. L. HERBERG
Ryan Aeronautical Co.

PLANT layout engineering has two objectives. One is to minimize direct manufacturing cost by providing: (1) efficient flow of materials, (2) accessibility of parts, tools, and materials, (3) satisfactory working conditions, and (4) proper grouping of functions for efficient supervision.

The second objective is to minimize indirect cost by: (1) obtaining high space utilization to reduce capital requirements, (2) planning layout flexibility to reduce rearrangement cost when program changes occur, and (3) providing a satisfactory layout at a minimum cost of execution.

Layout selection is often approached controversially from one of two con-

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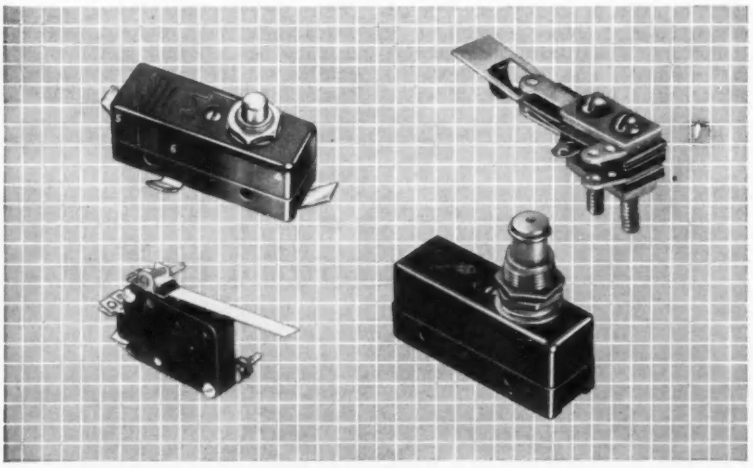

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cepts—product versus process. The product type has machines, processes, and assembly activity arranged by sequence of operations. The advantages claimed for it are reduced handling and temporary storage, lower materials handling cost, closer coordination, and highest output per man-hour. Process type layout calls for specialization by grouping similar type machines, processes, or skills of employees. The advantages are lower investment in equipment, concentration of supervisory attention, and product flexibility.

To make a sound selection of layout, the layout engineer must choose between the theoretical extremes of both types and come up with a layout that will be a physical expression of the relationship of these factors: management philosophy, company organization and personnel, product characteristics, and time and physical limitations.

The layout for parts storage is a choice between line stocking and individual stockrooms. Before any selection is made, the following factors must be considered: the type of product to be made, the type of final assembly area available, the percentage by weight of sub-contracted items, the fabrication area available for the backup of production, the gross roll-out weight of the product, the number and size of subassembly units going into the finished product, and the number of units to be produced per shift, per cycle of shifts, or per month. When the production rate is low, there is normally a sufficient assembly area for a true line stocking system. This reduces inventory control costs. When production is high and line storage area is at a premium, individual stockrooms must be used.

The objective of tool storage is to store the tools as close to the point of use as possible. However, the closer to the point of use, the more valuable the storage area because many items are competing for the same location. Therefore, the layout engineer must evaluate each case on its merits.

Tool storage should be considered from the three-dimensional standpoint rather than from area alone. Maximum use of the cube will reduce storage costs and minimize actual floor space requirements.

Office layout affects cost, speed, accuracy, and efficiency of all operations, involving clerical, technical, or financial personnel. This concept often has to be sold to management. Factors to be considered in layout are: the avoidance of backtracking, the centralization or spreading out of files, type of furniture, aisle space, lighting and air conditioning, reduction of distractions, communication systems, and possible expansion of personnel.

Layouts may be rejected because they are not properly sold. Good contacts should be maintained during formulation to convince all that the layout engineer has overlooked no one and to avoid the possibility of shock. That covers the institutional phase of selling. Then comes the close sale. The engineer must have just the right amount of confidence in his work, prepare it attractively, take pride in it, exhibit a thorough knowledge of the problems in answering questions, and choose a quiet area, free from disturbance, when putting his ideas across. (This article is based on the secretary's report of panel on plant layout held at SAE Aeronautic Meeting and Production Forum, Los Angeles, October, 1955. It is available in full together with 14 other panel reports as SP-313 from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: $2.00 to members, $4.00 to nonmembers. Panel leader was L. K. Pratt, Ryan Aeronautical; panel co-leader was R. D. Marks, Convair Division, General Dynamics Corp.; and panel secretary was R. L. Herberg, Ryan Aeronautical. Panel members were: E. F. Bentley, Solar Aircraft; R. G. Bower, North American Aviation; D. E. Hoyt, Douglas Aircraft; J. R. Matthews, Lockheed Aircraft; J. C. Potts, Boeing; and M. Uhler, Northrop Aircraft.

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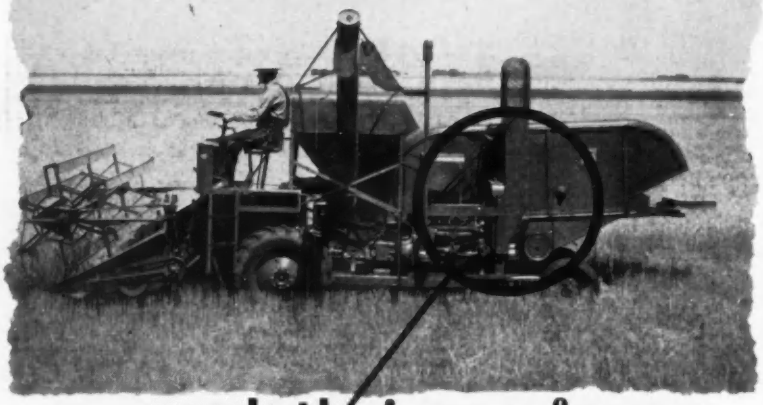

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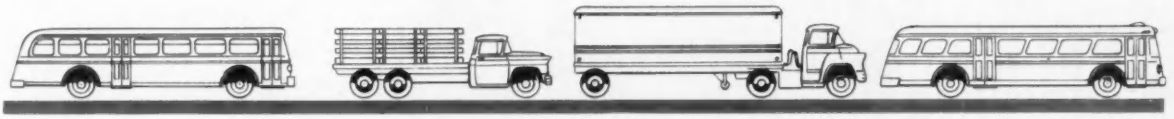
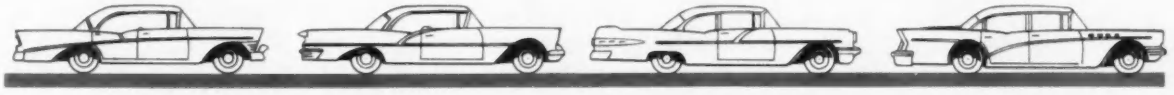


taper roller bearings



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Metallurgist's Work Vital in Hot Mill

Based on paper by

H. L. FARLING
Republic Steel Corp.

WHEN steel slab comes out of the furnaces at approximately 2250 F and continues through the mill, its temperature is constantly dropping due to contact with cold rolls and water from sprays to eliminate scale. The decreasing temperature causes the steel to go through various phases. There are certain phases wherein rolling or reduction or even plain bending of the metal results in physical structures incompatible with a final deep drawing automotive steel.

It is the metallurgist's job to see that there is no incompatibility, that a proper finishing temperature is arrived at for each particular grade, and that mill set-ups are such that a reasonably good product leaves the hot mill. The aim at all times is to finish roll the steel at a temperature of 1550 F, which is just above the Ar_3 point of the Iron-Carbon equilibrium diagram. (Paper "Flat Rolling of Automobile Steel" was presented at SAE Cleveland Section Meeting, May, 1955. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members, 60¢ to nonmembers.)

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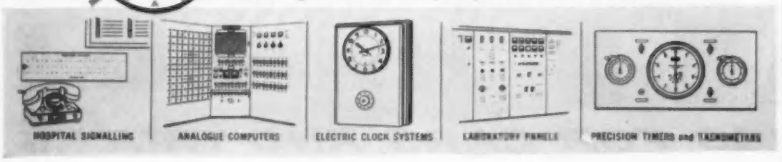

Coming! The Gas Turbine Locomotive

Based on paper by

R. TOM SAWYER
Alco Products, Inc.

THE gas turbine-propelled locomotive is the locomotive of the distant future. It will be able to handle any fuel prepared for it—gasoline, diesel oil, heavy oil, black coal, brown coal, wood, and heat direct from an atomic reactor. The burning of gasoline is not economical, but can serve in an emergency. Diesel oil will cost more in a gas turbine than in a diesel, but the use of heavy oil would bring the fuel cost in line with the diesel when used in the type of service found on the Union Pacific Railroad. The burning of coal in coal mining regions would make the fuel bill less than that of the diesel.

The Army Transportation Corps has a 300 hp gas turbine locomotive for experimental purposes. A mechanical transmission was selected to determine its advantages. The hydraulic torque converter was eliminated because the turbine has its own. During last winter no trouble was experienced with the Boeing turbines but the gear box failed and the trouble was traced to the control of the gears.

Undoubtedly, the mechanical drive is more suited to the gas turbine locomotive than to the diesel, but we don't know how big we can build a satisfactory locomotive with mechanical drive. We do know that gas turbine locomotives of 4000 hp and up, as used on the Union Pacific, must have electrical transmissions.

The gas turbine locomotive using nuclear fuel won't have to stop for fueling and it will cost less to operate, say around 1970. (Paper "Motive Power—Past and Future" was presented at SAE Metropolitan Section, New York, April 5, 1956. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members, 60¢ to nonmembers.)

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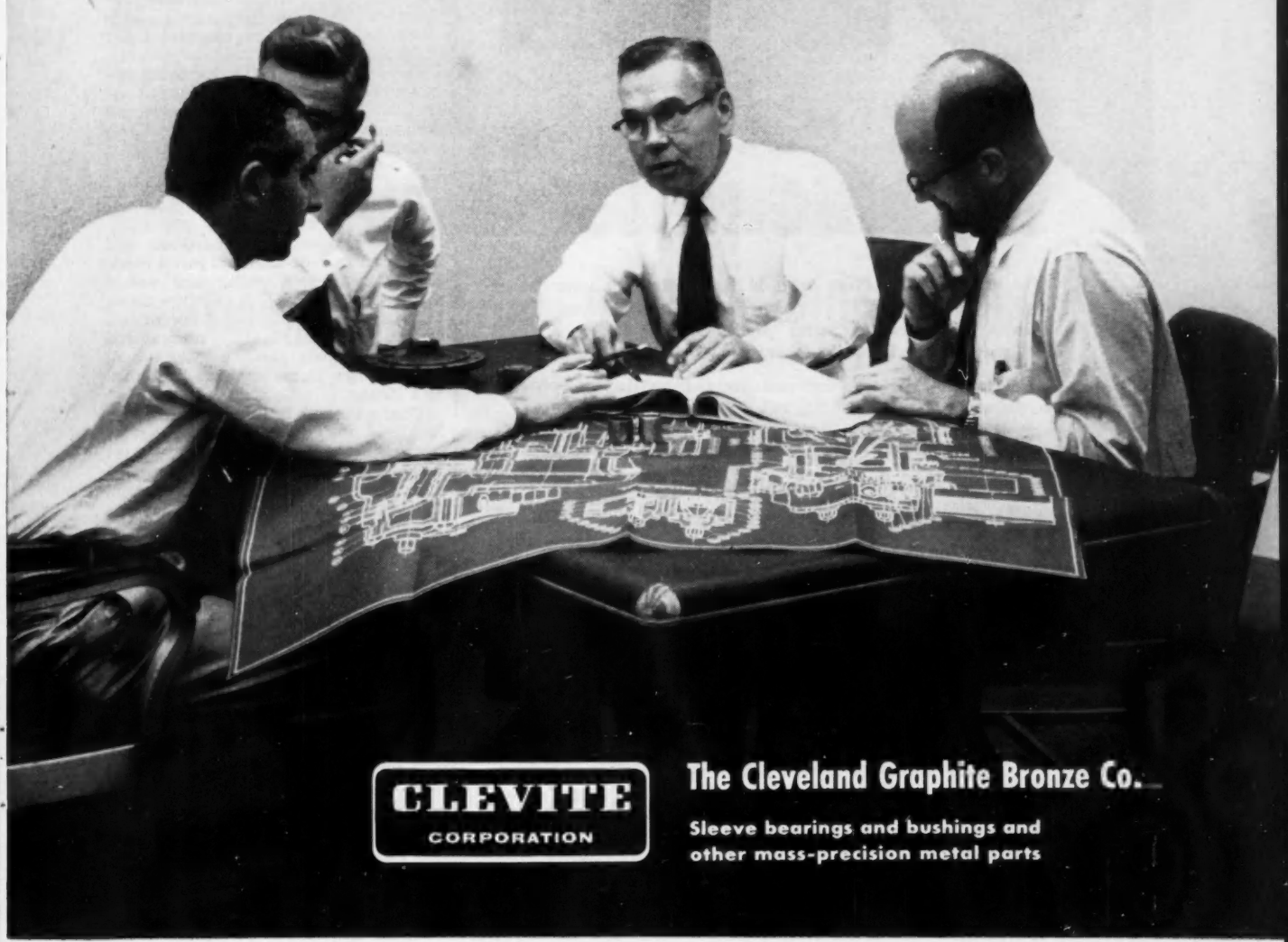

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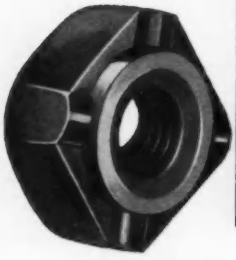

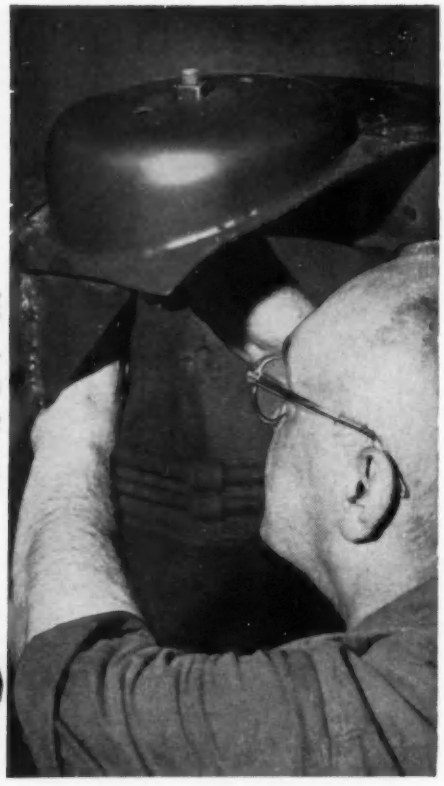

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New Transmissions Raise Gear Problems

Based on paper by

WILLIAM C. MERTENS
and
FRANK ZUZICH

Detroit Transmission Division,
General Motors Corp.

PROGRESS in production of gears for automatic transmissions will require simplification in design, more application of freer machining types of materials, closer control of the raw material, and development of new manufacturing methods.

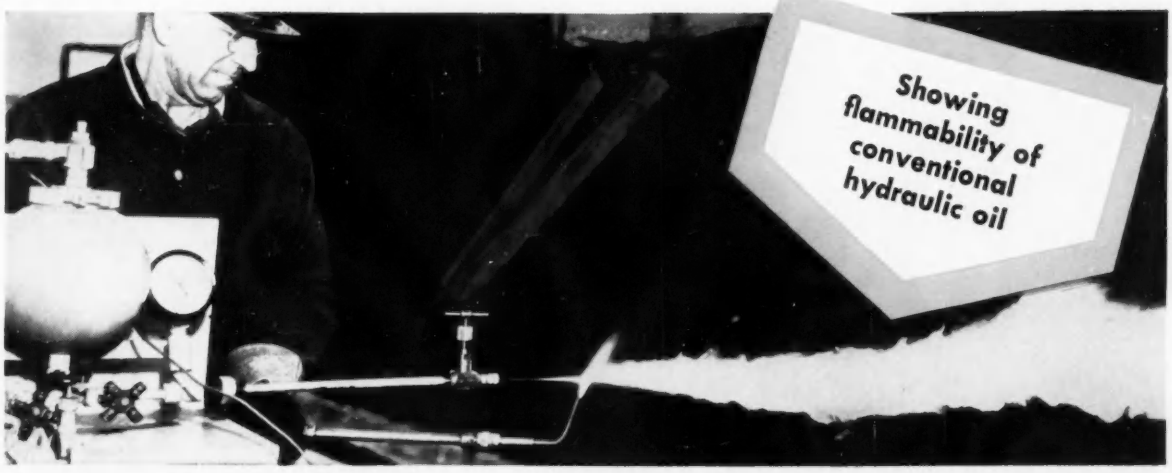
The design of gearing into symmetrical forms allows the use of bar stock and tubing raw materials which simplify handling, machining and tooling but raises other problems such as assembly of the elements. Development of press fits, staking, shrink fits or welding, can produce quality assemblies to be substituted for the complex, costly, one-piece forgings and castings.

Improvements in machineability are needed to permit extended production runs and more uniform cycle times, with fewer tool changes, to make best use of the concept of integrated manufacture. Further investigation of resulphurized steels and leaded steels should help to solve the machineability problem.

Closer control of the hardenability range is also needed. The present wide spread in hardenability can upset all phases of manufacture because of size change variations obtained in heat-treat operation. Further work is needed to improve the annealing and normalizing of raw material forms at the prime producers, such as steel mills. The wide variations in hardness and microstructure of identical steels made by different steel companies are a prime factor in tool life, surface finish and secondary machining operations. Better annealing and normalizing cycles will bring about greater use of primary raw forms such as bar stock and tubing.

Cold rolling or forming of gear tooth forms is one of the new methods of gear manufacture being developed with what appears to be excellent possibilities. The method is basically a centerless type, through-feed continuous one of rolling gear teeth on bar stock. Test samples show a prime factor in the success to be the uniformity of the raw material in hardness and microstructure.

The broaching of internal gears is fairly new in application to helical angle gears. The process has high productivity with low capital investment, lower tool cost, and saving of floor space. Careful engineering design is needed to get all the advantages of this gear cutting process, and machineability is very critical. Gear tooth defects such as tearing and pick-up are related directly to hardness and microstructure. Maintaining these raw



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Non-corrosive: Shell Irus Fluid 902 contains no corrosive ingredients. It has no harmful effects on seals, fittings or bearings. It does not promote rust.

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material conditions within uniform closely controlled ranges will allow gear producers to take advantage of the process.

Study of casting methods to obtain more precision as-cast dimensions to eliminate or minimize machining, is a continuous development. Alloys are being developed for greater homogeneity in structure and heat-treat response. Development of these alloys to get higher physical properties while retaining present machineability will allow greater application of castings to automatic transmission gears. (Paper "Automatic Transmission Gear Materials and Associated Problems" was presented at SAE Passenger Car, Body, & Materials Meeting, Detroit, March 7, 1956. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members, 60¢ to nonmembers).

Road Rebuilders Ask Equipment Adapted to Needs

Based on paper by

RUFUS S. KIRK,
County Engineer, Sedgwick County, Kansas

THE race for size and power in road machinery has gone too far for road rebuilders. We would like machines better adapted to our needs. We aren't interested in bigger machines.

We want machines which will:

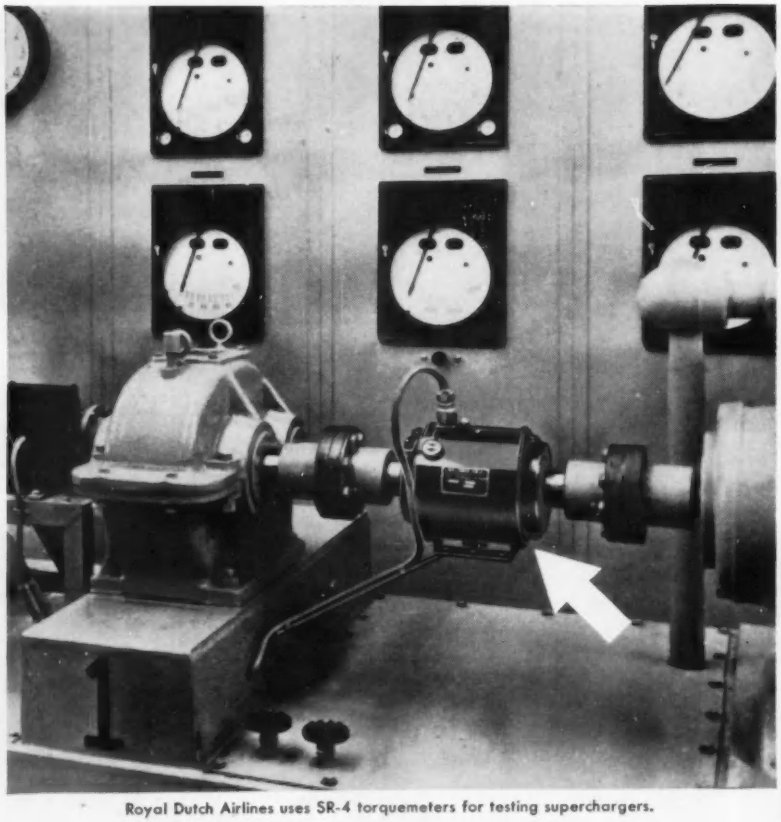
- Give a better surface finish to our roads;
- Give less vibration and noise to our operators;
- Give improved safety both on the project and in traffic (which can't always be detoured.)

To get our better surface finish, for example, we would like motor graders, rollers, and even scrapers with controls having smaller, but positive increments of adjustment. We'd like them more rigid, too. In manufacturing parlance, we want our planers to cut more accurate surfaces, because rough roads produce vehicle impact which is more destructive than weight.

Much already has been done for operator comfort, but we suggest still less rigid cushions, thicker and softer mats, and more effective mufflers.

And we think safety could be helped by such devices as back-up horns and automatic turn-signalizers of some type.

(Paper "Rebuilding Ruined Roads with Machinery" was presented at the SAE Central Illinois Section Earthmoving Industry Conference, Peoria, April 4, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members; 60¢ to nonmembers.)



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Airlines Face Problem Of Turbine Overhaul

Based on paper by

NORMAN R. PARMET
Trans World Airlines, Inc.

DESPITE the military's extended experience with turbine engines there are many unknowns regarding their operation and upkeep. Airline operators would like to know, for instance, what it will cost to operate, maintain, and overhaul the engines that will power their new transports.

The ability to operate for long periods between engine overhauls will be one of the greatest factors influencing operating cost of a turbine powered transport. Yet, extended overhaul periods cannot be attained at a penalty in parts replacement costs. Since overhaul costs are one of the major items in direct operating cost over which the airline has some degree of direct control, here is where the manufacturer and airline can contribute the most to economic operation.

The airlines would like to know when the military is likely to take the wraps off some models of turbines. Unfortunately, the types most like future transport engines are the ones most closely shrouded.

A high degree of utilization is essential for economic success, and that requires engine reliability. But there is a tendency on the part of some manufacturers to increase the schedule time between overhauls by requiring partial engine disassembly periodically between the start and end of the scheduled overhaul period. This could raise costs by requiring more spare engines and critical engine components for interchange purposes. Realistic overhaul periods should be established, capable of attainment by the great majority of operating engines.

At the present time it is not known what overhaul shop facilities will be required. A major problem may arise in conversion of existing facilities. Many turbines require vertical assembly and disassembly and this may not be feasible because of limited overhead clearance. Manufacturers should examine their designs to assure that vertical assembly won't be necessary.

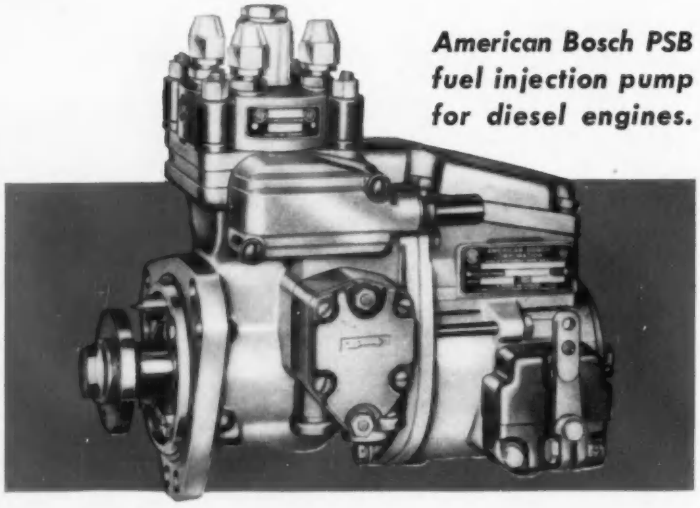
Are engine manufacturers going to furnish inspection procedures and techniques before turbines are placed in commercial use? Extreme operating conditions introduce problems unknown in piston engines. Whatever information is provided must be detailed and not subject to wide latitudes of interpretation.

If new skills are needed in the overhaul shop and line maintenance organizations, what will they be? It would appear that the greatest amount of training will be required of personnel assigned to fuel control overhaul and testing. Mechanics will have to be educated to keep tools and nuts and bolts away from engine inlets if engine damage is to be held to a minimum.

The airline industry has grown up with the throttle mixture and rpm controls. But judgment must be reserved on the single power lever concept until assurance is given that turbine engine fuel control can apportion fuel to meet all desired operating conditions and prevent operating in a manner detrimental to the engine.

Whatever the manufacturer's philosophy with respect to replacement engine components, the lead time for parts procurement should not exceed three months. With piston engines the lead time often runs as high as six months to a year. This requires the airline to maintain a large shelf stock, which ties up capital and floor space.

Most airlines prefer to recondition



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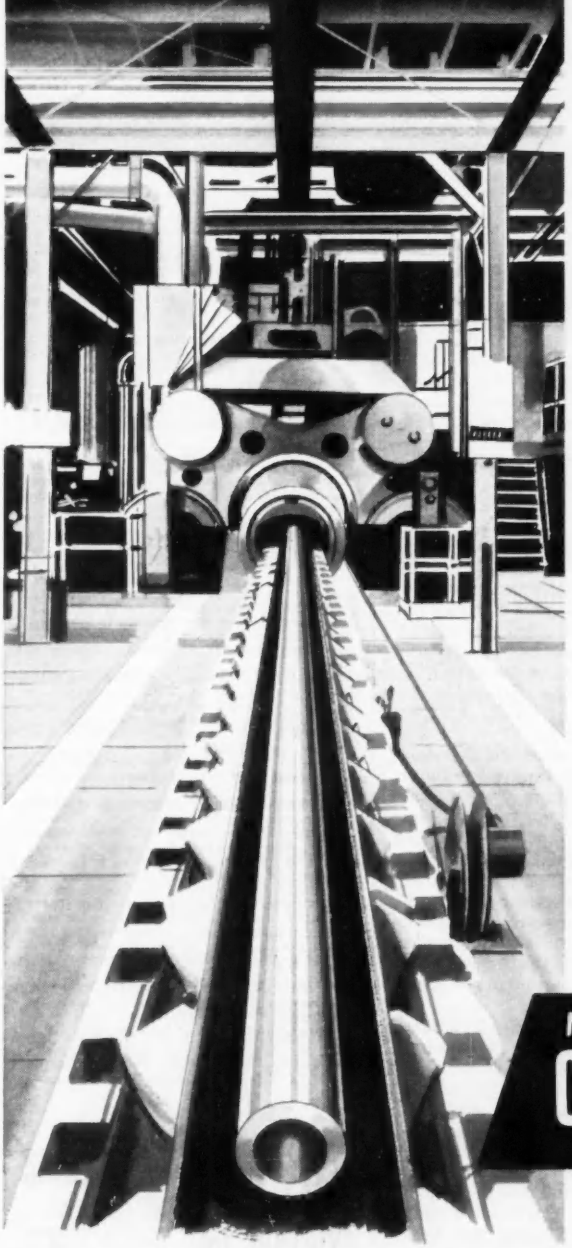

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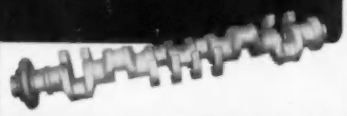

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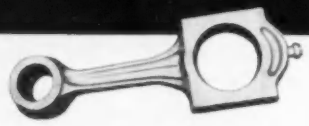

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their own parts for economy reasons. Many piston engine components can be plated and machined to fit manufacturer's original tolerances, but there is often difficulty in getting new part blueprint dimensions as a guide to reconditioning. Manufacturers' manuals have shown great improvement over the past five years and it is to be hoped that this trend will continue in the gas turbine overhaul manual. (Paper "Turbine Engine Overhaul Problems—A Challenge to the Air Transport Industry" was presented at SAE Annual Meeting, Detroit, Jan. 11, 1956. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members, 60¢ to nonmembers.)

Problems of Designing High-Speed Test Roads

Based on paper by

WILLIAM A. McCONNELL
Ford Motor Co.

FORD engineers have tried a new approach to designing a test road system simulating a long straight road by means of a closed track. They have studied motion sensitivity of the human being and tried to design the curves of the track such that neither occupants nor vehicle suspension can tell that the vehicle is in a turn. This is a departure from the usual design procedure.

This new procedure is based on the perception threshold data of humans, as opposed to the usual procedure which is based on an understanding of the dynamics of highway geometry. The new method considers translational and rotational components of motion. In design of the track, attempts were made to get total motion components below the threshold so that the appearance of a long straight road is given at high speed.

Using this new procdure, the dips and turns in the road are shaped to give the preferred ride motion. This is done by determining what roll motions humans feel at the planned speed of the track and adjusting the track design to give a feeling of riding on a level road. The first step is to determine approximate shape of the track and the radius of the turns. Next step is to determine the shape of the transition spiral connecting the straight and curved portions.

The resulting test track establishes suitable working limits to the magnitude of the perceptible characteristics of motion. (Paper "Motion Sensitivity as a Guide to Road Design" was presented at SAE Summer Meeting, Atlantic City, June 5, 1956. It will be published in full in 1957 SAE Transactions. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members, 60¢ to nonmembers.)

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Du Pont is engaged in a program to train these men. Experienced representatives, using dynamometer equipment, demonstration engines, and instrumented test cars are teaching thousands of gasoline dealers the principles of car performance. The Du Pont men are able to show, at oil company dealer meetings, how engine design and maintenance, as well as fuel quality, affect automotive performance. The demonstrations show how spark and carburetor settings can cause knock, the effects of fouled spark plugs and faulty ignition systems on power output, and how temperature, altitude and atmospheric conditions affect performance.

We expect the results of this program to be rewarding to the automotive as well as to the petroleum industry. Just drop us a line if you would like to know more about this unique service program.

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Designing Earthmovers For Easy Servicing

Based on paper by

F. A. GROOSS
Caterpillar Tractor Co.

MUCH can be and should be done to design earthmoving equipment to make servicing easier and more effective. Take greasing, for example. Grease fittings call for service every 10 hr, every 20 hr, and serving every 100 hr. This makes for confusion. One tractor-scraper manufacturer specifies greasing the scraper every 10 hr and similar fittings on the tractor every 20 hr. As a result, everything or nothing gets lubricated.

Why not establish common service periods? The fittings have been pretty well standardized as to size. Now we need to reduce their number, make them more accessible, and extend service periods by providing better sealing and greater reservoir capacity.

Dirt clearance should be provided around reservoir breathers, dip stick holes and filler pipes. Filler caps and dip stick caps need deep skirts to keep necks clean and prevent dirt from entering while servicing. Filler caps and covers with keepers would prevent misplacement and loss.

Dip sticks, filler necks, and breathers should be located where they are easily seen. Dip sticks which are easily reached, legible and accurate are better and safer than level plugs. Drain plugs shouldn't drench the service man when removed, yet drain the compartment adequately.

Filters should be placed in accessible locations. Compartments ought to be combined to reduce the number of filters and the number of types and sizes of filter elements needs reduction. Along with this should go a limit on number and types of oils and greases.

Oil and air lines should be neither all flexible, nor all rigid. Flexible lines are difficult to support; rigid lines are hard to assemble and subject to breakage. Rigid lines for fixed locations and flexible sections for relative movement and ease of coupling seems to be the best compromise.

Service can be eased by using pilots for locating units, chamfers for guiding, puller holes and slots for part removal, and stepped or tapered shafts for ease of assembly and disassembly. Parts should be designed so that they can be assembled only in one particular manner and location. That would prevent bevel gears from being assembled backward and axle shafts of unequal length from being assembled incorrectly.

Adjustments for bearings should be simple and foolproof in design. They get more critical as bearing and component sizes increase. The weight of the wheel and tire assembly alone makes adjustment critical for the ordinary field service man.

Linkages such as those used to operate cable control units or hydraulic units should have the fewest possible adjustable levers. Service people in the field are lost when confronted with multiple adjustable rods or levers in a linkage system. They don't know how to set levers for maximum mechanical advantage. This has to be designed into the unit.

As units become larger, parts get bigger and heavier. Parts must be held down in weight and size for easy handling. It is difficult to design unit assemblies for large machines and still hold down part size without having an excessive number of pieces and connections. (Paper "Designing for Serviceability" was presented at SAE Central Illinois Earthmoving Industry Conference, Peoria, April 3, 1956. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members, 60¢ to nonmembers.)

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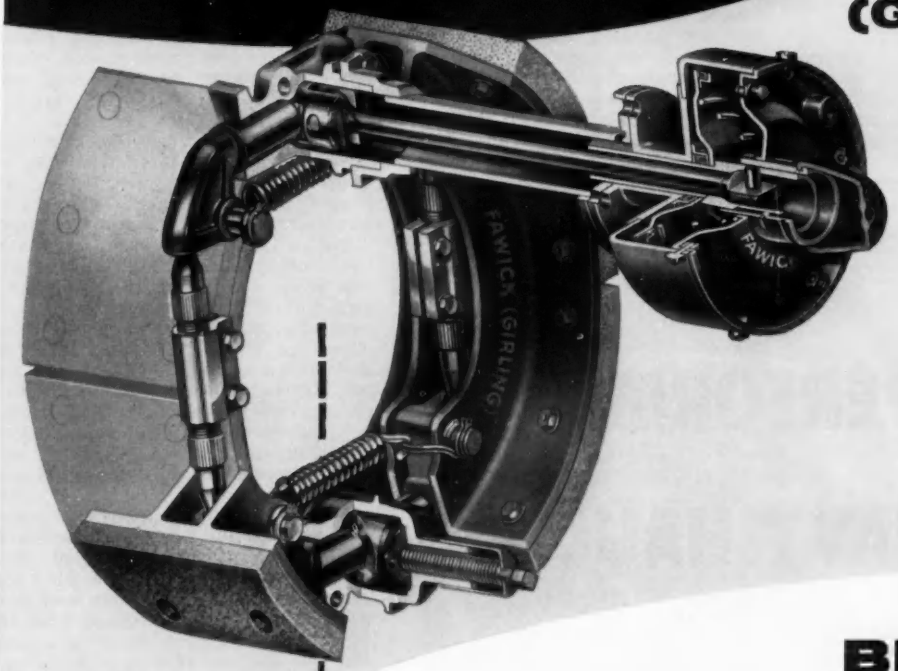

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Based on paper by

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There are two categories of flexible plastic foams, the urethanes (Vibrafoam) and vinyl chloride (Vinyl Foam). They have, generally speaking, an interconnecting cellular structure, although unicellular structures are available. Ensolite is one example. They can be made to be soft or hard, resilient or dead, light or dense, and with properties in between these extremes. They can be made in slab form or molded shapes, and they respond to all conventional fabricating techniques including several new ones such as foaming in place, dielectric sealing and tooling, and heat forming.

Urethanes of the polyester type have a high indentation load deflection while the density is low. Flex one at a point of 50% deflection for several thousand cycles at slow speeds, or at only 5% for several thousand cycles at high speeds and the indentation load deflection is found to decrease from 20 to 50%, depending on the composition, and this does not recover on standing. For this reason these urethanes can be used to advantage only where the load is applied occasionally. They also have been known to degrade after one or two years shelf aging. On the other hand, they have good resistance to solvents, oil, ozone, and dry heat, and low flammability.

Polyether urethane does not exhibit the same type of degradation at elevated temperatures and high relative humidities. Its stress strain properties under compression are more like those of conventional foams, and indentation load deflections values decrease less. But it has less load carrying capacity, less resistance to solvents and oils, and is more flammable.

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Vinyl foam can be heat sealed or tooled by dielectric machines. Heat of 300 F or more is required for proper fusion in application. Hence it cannot be foamed in place as readily as the urethanes. It has outstanding resistance to ozone, moisture, mildew, gas combustion products, and other agents causing rapid degredation of other foams. Ketones and similar solvents attack it. Non-flammability is

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Multi-Vis Oils Good But Have Their Lacks

Based on paper by

WILLIAM A. HOWE

Gulf Oil Corp.

ENGINE deposits can be controlled; wear on piston rings, cylinder walls, and valve train parts can be minimized; and some relief can be had in preignition and octane requirement increase if adequate levels of detergent agents and anti-wear agents are used with properly selected and refined distillates or with almost all distillate base oils.

Some oil producers believe these advantages can be had only with a high viscosity index, multi-vis type of oil, which is generally a light distillate plus a relatively large amount of viscosity index improver. Others think similar results can be had with natural SAE grades.

Tests show that high additive oils will minimize engine deposits in valve lifters, oil control rings, oil screens, and other areas of the engine. With an anti-wear agent added, corrosive wear and rust and wear on valve train parts will be minimized. Current SAE 10W/30 as well as properly selected and refined natural SAE grade oils will help to minimize preignition and octane requirement increase, but SAE 10W/30 oils made under currently accepted formulations have several undesirable features such as tendency toward intake valve deposits, body breakdown, and higher consumption characteristics. (Paper "Modern Oils for Modern Engines" was presented at SAE Cincinnati Section Meeting, May, 1955. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members, 60¢ to nonmembers.)

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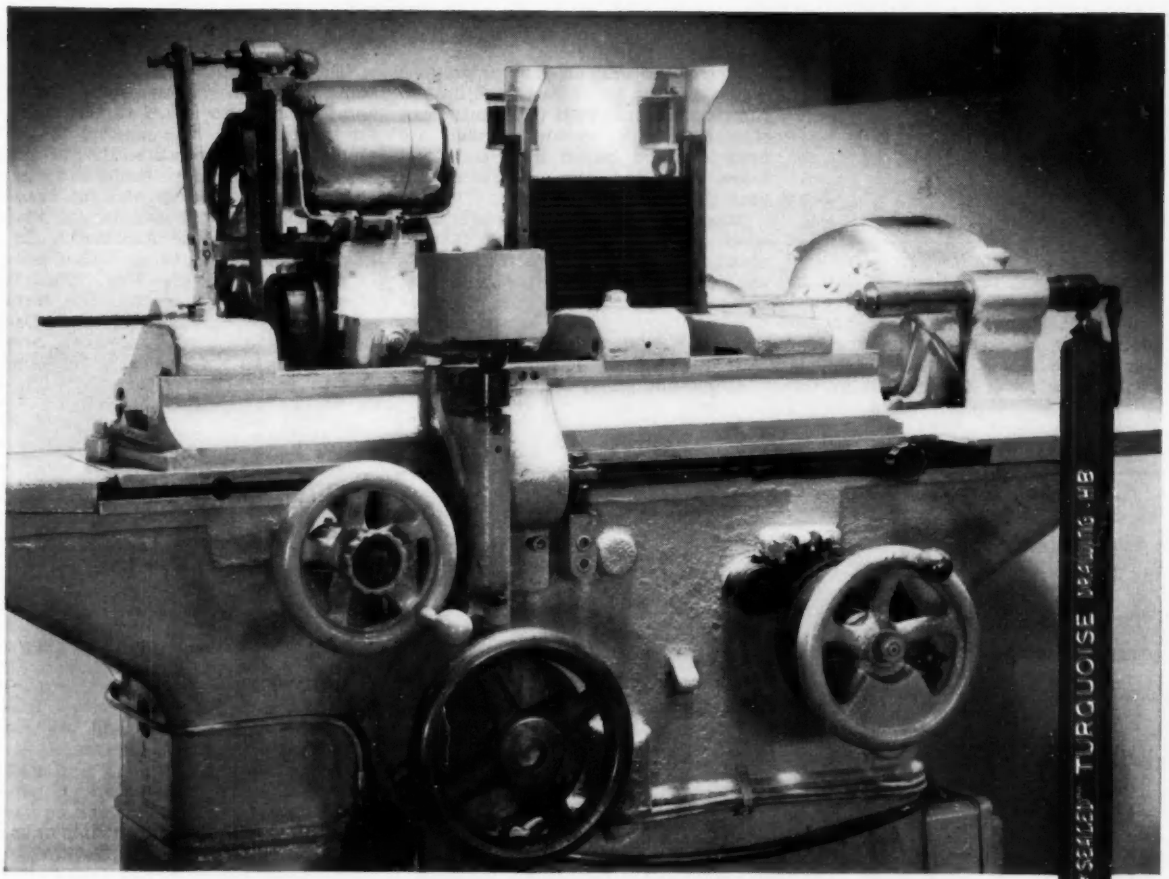

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It sharpens *all* test leads, thick or thin, hard or soft, Eagle or competitive, down to a cylindrical point of .050″ diameter (± .0001″) as illustrated at right. You can see that such a "point" will present a constant area to the paper throughout any test and will let us compare smoothness, durability or opacity on a fair and equal basis.

It will also sharpen at any desired angle, creating identical long-tapered drafting points for needle-point strength tests.

The results enable us to test our research, confirm our improvements and maintain our quality. Whether *you* sharpen your pencil by knife, razor, sandpaper block, or regular pencil sharpener, remember Two-Ton Tillie. It's part of Eagle's continuing research to *keep* TURQUOISE the finest drawing pencil in the world.

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Steel Making Is a Developing Art

Based on paper by

H. E. CRAIG

Republic Steel Corp.

IN the working of a rimming heat in an open hearth furnace, the steel must contain enough oxygen at tap to produce the desired rimming action in the molds. The general rule is that the lower the carbon in the heat, the less difficult it is to produce a slag suitable for creating the desired rimming action. This takes into consideration ladle additions which are predetermined by an iron oxide test taken from the furnace before tapping the heat. It also assures having a good heat of proper specifications when the ladle leaves the furnace stand for the pouring platform. When the heat is poured into the molds, the balancing of oxidation and deoxidation are accomplished again by additions. These may increase or retard the rimming action as desired.

Aluminum killed steels are treated in the ladle with higher aluminum additions than rimmed steels, and aluminum is also added in the molds for deoxidation. The purpose of the aluminum is to insure the proper grain structure for deep drawing. (Paper "Open Hearth Melting Practices Related to Production of Flat Rolled Steel for the Automotive Industry" was presented at SAE Cleveland Section Meeting, May, 1955. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N.Y. Price: 35¢ to members; 60¢ to nonmembers.)

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Transmissions—Where They Go from Here

Based on paper by

FOREST McFARLAND

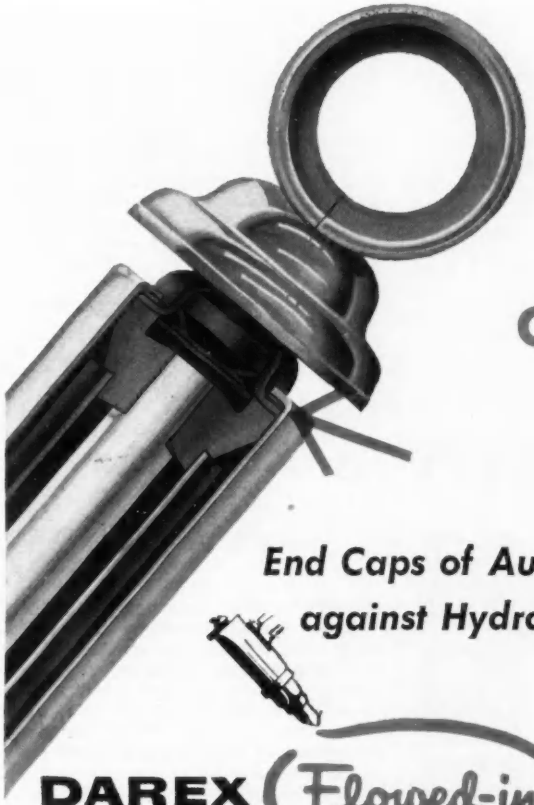
Studebaker-Packard Corp.

THERE are two schools of thought regarding engines and automatic transmissions. One school would use low numerical axle ratios and relatively small engines, load them up, and shift gears frequently as the need for performance arises. Economy can be had with this type of design, which is in use today.

The other school leans to the use of reasonably large engines with low numerical axle ratios. The engines would be designed to give performance equal to or better than our present ones in direct, and much better part-throttle economy, so that their somewhat "oversize" would not require too much premium in lessened fuel economy. A definite gain in performance then would be possible by full accelerator pedal depression without frequent gear shifting. Further gains could be had by shifting gear ratios. Transmissions would be kept at a minimum. But this arrangement cannot be had without a large amount of basic work on engines.

In any case, engines, transmissions, rear axles, and car weight will have to be thought of as a single package before the goals of economy, performance, smoothness, and cost can be set up.

We can be certain there will continue to be an immense amount of work on new designs for getting the automobile under way so as to give the customer something he will like better than his present unit. (Paper "Automatic Transmissions — Past, Present, and Future" was presented at SAE Buffalo Section Meeting, January, 1956. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members, 60¢ to nonmembers.)



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COMPOUND: N779	
One of several standard DAREX "Flowed-In" compounds now being used by the automotive industry	
Base	Neoprene
Heat Resistance	good to 300°F
Oil Resistance	excellent
Gasoline Resistance	good
Permanent Set	30-35% ASTM Method B
Color	brown
Consistency — Wet	thick paste
— Dry	rubbery, Shore A hardness 30
Production Rate	
— Automatic	80/min
— Semi-Automatic	40/min
Vulcanizing Time	5 — 10/min
Uses:	Wherever gaskets must seal against oil leakage or pressure, as on electric motor bearing caps.

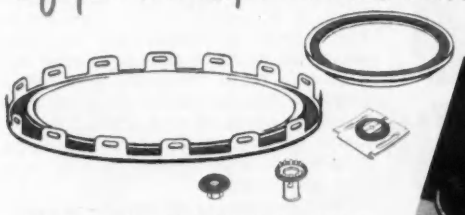
Automotive parts manufacturers, who had used electric welding to seal shock absorber end caps, are now saving thousands of dollars yearly by using the new DAREX "Flowed-in" Process.

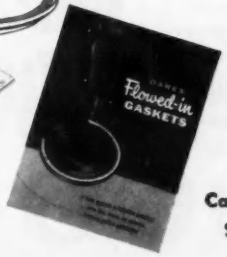
Dewey and Almy engineers, after studying the problem, recommended "Flowed-in" gaskets with a DAREX compound. This gasketing material is flowed into place as a liquid, then vulcanized to form a solid, rubbery seal that is unaffected by oil under heavy pressure and temperatures up to 300°F.

End caps are now gasketed and cured, automatically, on a sub-assembly line, doing away with the costly welding process in final assembly line. Production has increased. The overall cost of sealing is much less. Rejects due to "leakers" have been practically eliminated.

Perhaps the DAREX "Flowed-in" Process can increase production or quality of *your* product. And at the same time lower labor and materials costs. If you have a problem involving a circular gasket, cushion, seal, or vibration dampener—send today for the DAREX "Flowed-in" Gasket Brochure illustrated below.

If you make parts like these—





discover what DAREX "Flowed-in" Gaskets can do for *you*. Write for this brochure *today!*

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Impact Extruded Parts Enter Automotive Use

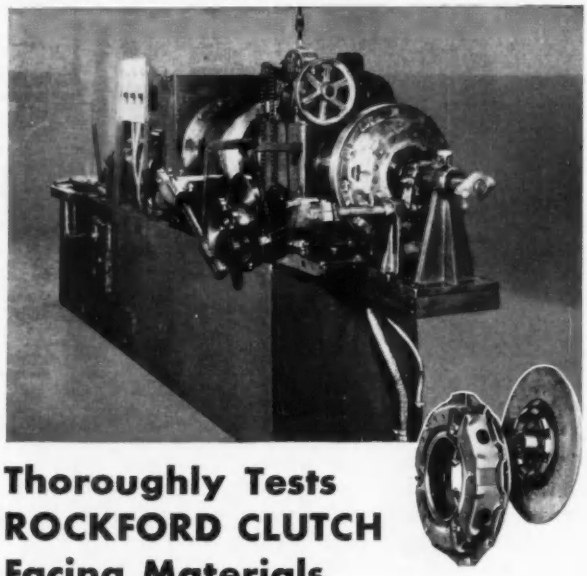
Based on paper by

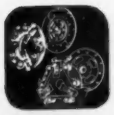
NORMAN OLSEN
Aluminum Co. of America

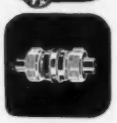
ALUMINUM impact extrusions are produced with draft-free surfaces, having closer tolerances than forgings, and they can be designed with thinner sections and with more detail. Their superior mechanical properties and soundness of metal structure cannot be duplicated by castings. One-piece seamless impact extruded parts can often replace welded or assembled products and thus reduce cost.

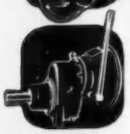
Impact extrusions designed for automotive use include: Wheel brake pistons, protective covers for spark plugs, torque reaction shaft and servo pistons for automatic transmissions, as well as components for power brakes, power steering, power window lifts, shock absorbers, speedometers, and lubricating devices. (Paper "Impact Extrusion of Aluminum" was presented at SAE Central Illinois Section Meeting, December, 1955. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members, 60¢ to nonmembers.)

ROCKFORD









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To record the durability and heat resistance of current and newly developed friction material, for ROCKFORD CLUTCHES, two driven-member assemblies are assembled with two flywheels and clutch cover assemblies.
The automatic rotating cams of the engaging device produce repetitive engaging and disengaging cycles of the driving clutch and braking clutch assemblies. 10,000 engagements and disengagements, four cycles per minute, give a very conclusive wear test on the friction facings. The repetition and standardization of this test procedure constitute an accurate analysis of the wearing quality of friction facing materials used in ROCKFORD CLUTCHES.
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CLUTCHES

New Materials Cry for Exploitation

Based on paper by

PAUL E. LAMOUREUX
Trans-Canada Air Lines

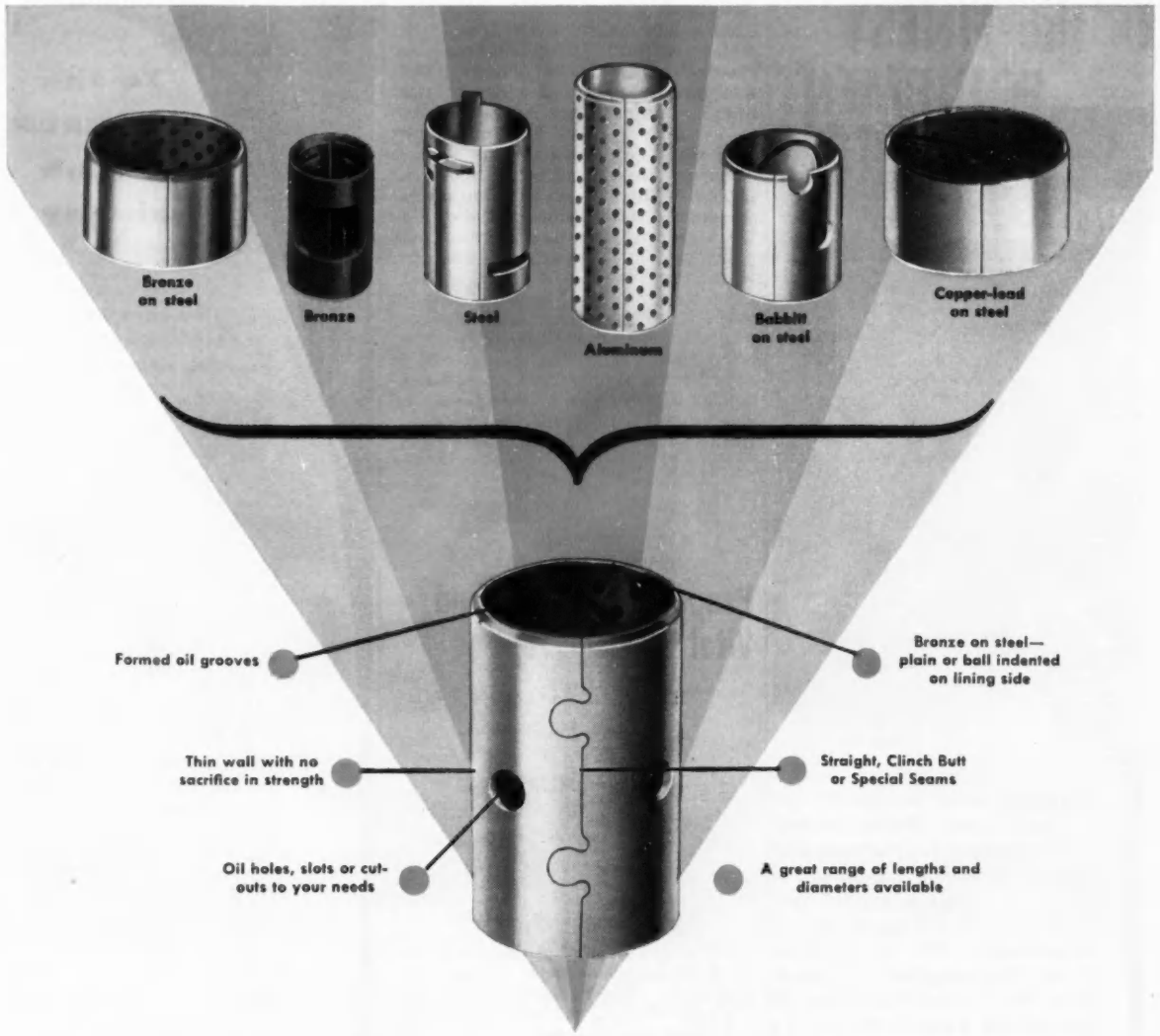
DOWN-to-earth improvements rather than glamour features the newer materials. Among the synthetics, for example, is the family of polymers known as the polyurethanes which have properties so remarkable that more concerns are betting on them commercially than on any other new polymer.

First major product to come from the polyurethanes is a flexible foam having some properties superior to latex foam rubber. The foam may range from very soft to rigid. It is so tough it can be sewn (as latex cannot.) It withstands laundering and dry cleaning well (which latex does not). It has exceptional resistance to ozone and sunlight which quickly ruin latex.

The polyurethanes make excellent adhesives and surface coatings. They hold promise of providing a new solid rubber capable of making tire treads that will outlast present ones by a factor of at least 2½ to 1. Such a tire would probably last 100,000 miles, or even outlast the car.

Ceramics, while not new, can be classed as such since they now have a range of properties qualifying them for solving tough problems. In many ways they seem to have taken over where prima donna materials fall flat on their faces. The melting point of ceramics ranges from 1100 to 6500 F; compressive strengths range from 50 to 332,000 psi; expansion coefficients from 14 to −6 ($\times 10^{-6}$); resistivities from those of conductors, through semi-conductors, to extremely good insulators. While ceramics are being used, the field is hardly touched, and engineers would be well advised to acquaint themselves with the concealed virtues and better known vices of this class of materials.

Ceramic coating of metals is especially worthy of note. It promises extended service life for such parts as aircraft engine exhaust components, automotive exhaust valves, and fur-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No matter what the specific job—clearing land, ditching for irrigation, grading for railroads and highways, laying pavement or wrecking buildings—you'll note a pronounced swing, of late, to equipment with Continental power. The adoption of dependable Red Seals—gasoline or Cushioned Power Diesel—by more and more builders of construction and industrial equipment, reflects a spreading recognition on the part of machine users, of this basic fact: There's a vast difference, in performance, dependability, economy and upkeep cost, between the ordinary engine and the Continental Red Seal that's engineered and built for the job.

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PARTS AND SERVICE EVERYWHERE

Continental Motors Corporation

MUSKEGON AND DETROIT

nance heating elements. Ceramic films 0.001 to 0.003 in. thick are fired on the metal surface. The coatings are claimed to be tightly adhesive, flexible, resistant to abrasion and thermal and mechanical shock, and impervious to corrosive gases. Welding of the base metal can be carried on without removing the coating which melts and acts as a flux. It is understood that jet engine flame tubes fabricated in low alloy steel and ceramic coated are being used in place of more expensive alloy flame tubes in some U.S. military aircraft. (Paper "New Materials for Today and the Future" was presented at SAE Montreal Section Meeting, April, 1956. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N.Y. Price: 35¢ to members, 60¢ to nonmembers.)

Proper Frame of Mind Vital to Field Testing

Based on paper by

HYMAN FELDMAN
New York City Transit Authority

JAMES P. MORELAND
Fifth Avenue Coach Lines, Inc

and

E. N. HATCH
Department of Franchises, Nassau County, N.Y.

ONE of the greatest paradoxes in fleet maintenance is field testing. It is a woefully pathetic system for obtaining information, yet no laboratory in the world can duplicate it. Thousands of external factors can distort the evaluation of a product's performance in the field, but the finest of isolated technical instruments cannot determine its merits more exactly. It is the ultimate determination of the ability of a theory to withstand nature's elements, a driver's temperament, the city's traffic, and a mechanic's mistake. It is the transformation from the perfect science of dynamometer rooms to the imperfections of operating conditions.

A most important requirement for successful, continuing field testing is frame of mind. In many instances, individuals concerned either directly or indirectly are anti-test. Consequently all conclusions based on judgment are smiled upon, while most conclusions based upon scientific testing are frowned upon. This may sound ridiculous and childish, but such situations do exist in numbers sufficient to represent a serious problem. Two simple methods can be used to combat this unhealthy condition. First, individuals on the executive level, once convinced, may order those individuals

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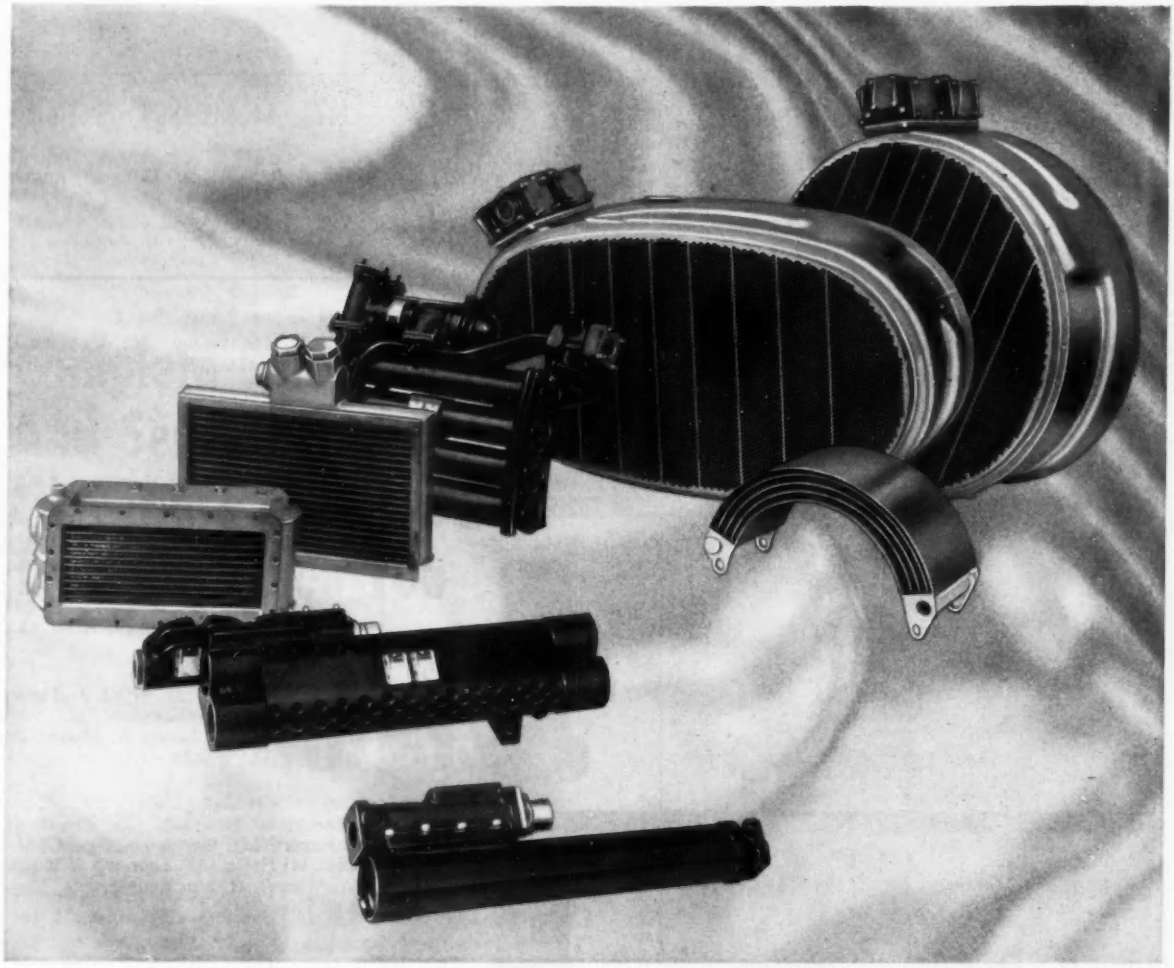

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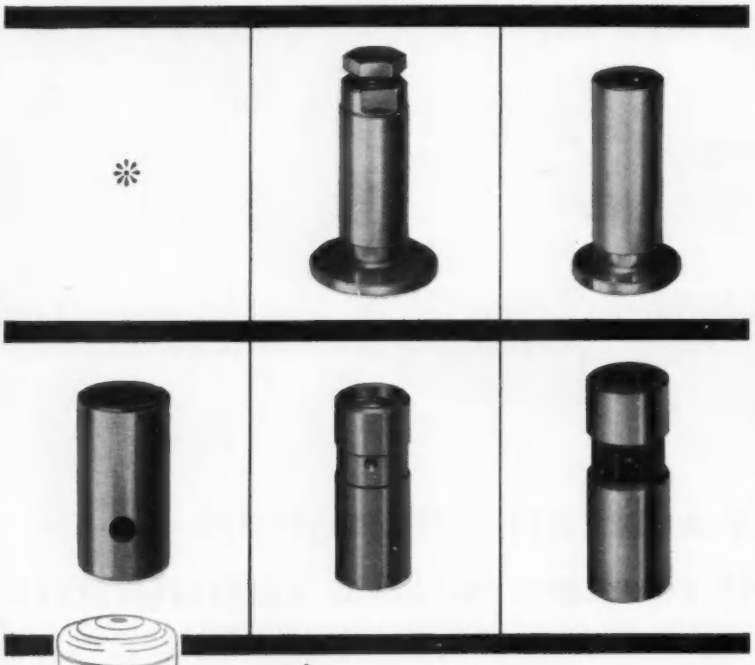
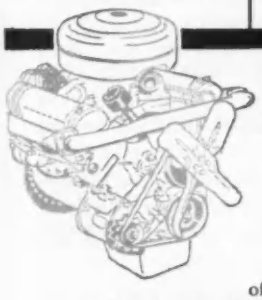
concerned to be convinced and govern themselves in accordance. The second way, and a better one, is to convince the skeptics with examples, particularly with those which make jobs easier and more economical.

The small bus operator has better control than the large operator because he knows every unit and practically the life of every individual part on his small fleet. He is running tests continuously, although he might not refer to what he does as a test procedure. It is done automatically as soon as he finds a part does not give him satisfactory service. He will look for a different product, obviously affecting his purchase habits. (Paper "Field Testing of Parts and Supplies" was presented at SAE Summer Meeting, Atlantic City, June, 1956. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members, 60¢ to nonmembers.)

JOHNSON *tappets*





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New Members Qualified

These applicants qualified for admission to the Society between August 10, 1956 and September 10, 1956. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Atlanta Section

Charles G. Habley (M), Charles F. Marschner (M), Samuel R. Osborne (A).

British Columbia Section

R. H. Garrett (M).

Buffalo Section

Ellsworth A. Kehoe (M), Robert H. Meyerhans (M), Richard F. Thurston (J).

Canadian Section

E. R. Current (A), David Kidd (A).

Central Illinois Section

John S. Eisele (J), Niles J. Fisher (A), Edwin M. Kirchgessner (M), Vincent Licari (M), James A. Moore, Jr. (M), Gus M. Waeltz (J).

Chicago Section

Harold L. Bowman (J), Frank G. Elmlinger (M), George A. Grant (M), Elmer M. Holtz (A), Leonard J. Kowal (A), Warren R. MacKenzie (M), Martin S. Vasek (J).

Cincinnati Section

Abram D. Reynolds (A).

Cleveland Section

Benjamin Barish (M), Ralph B. Beardsley (M), Robert T. Drake (M), Arthur E. Franke (J), C. A. Hulsemann (A), John B. O'Donoghue (A), Howard Peeples (M), Fred A. Sheplavy (J), Clarke F. Thornton (M), Harry M. Valentine (M).

Colorado Group

T. Jay Paxton (A).

Dayton Section

Alfred R. Brenholts (M), William B. Stelzner, Jr. (M), James L. Tunney, Jr. (J).

Detroit Section

William J. Andrews (A), Earl P. Beach (M), James P. Beakley (J), Wayne V. Brien (M), Arnold R. Brown (M), LaVerne D. Brown (J), Robert L. Collins (M), Don B. Ellis (M), Anthony J. Gicius (A), Harlan L. Hanson (J), Wallace S. Holbrook (A), Drew S. Holt (M), Robert I. Homier (M), Robert Leslie Jones (M), George A. Kendro (M), Byron J. Kerry (A), Charles L. Knighton (J), Walter H. Langrill (M), Robert Mescher (A), Fay J. Miller (M), Robert M. Phillips

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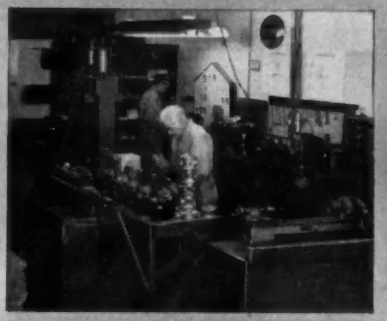
This up-to-the-minute parts department belongs to B-W Brake Company, Midland's Distributor in Kansas City, Mo.

Wherever you are, there's a Midland Distributor nearby who's anxious and ready to serve you — a fully-equipped Midland Sales and Service Headquarters where you can be sure of getting the complete, most satisfactory answer to your power brake needs.

Shown here are views of typical sales and service facilities in Midland's chain of more than 250 Distributors covering the United States and Canada alone.

Yes, wherever you are, throughout the world, you can get complete Midland Power Brake kits or buy genuine Midland parts from a nearby Midland Distributor. And wherever you are, there are experienced Midland mechanics to provide you with instant, efficient service when you need it.



A view of part of the Midland Power Brake service facilities operated by Motor Rim & Wheel Service of California at its Los Angeles headquarters.

THE MIDLAND STEEL PRODUCTS CO.

6660 Mt. Elliott Avenue • Detroit 11, Michigan

Export Department: 38 Pearl Street, New York, N. Y.

Exterior and interior views of the main sales and service set-up of Southwest Wheel, Inc., a Midland Distributor with branches throughout Texas and Oklahoma.

New Members Qualified

Continued

(M), Richard S. Schuster (J), James D. Smart (J), C. M. Stordahl, Jr. (J), William P. Strong (M), Terrance N. Todd (J), Kenneth J. Whitledge (J), George P. Yee (J), Donald J. Zweng (M).

Hawaii Section

John Andrade, Jr. (A), Frederick Bolte (M), David M. Burns (M).

Indiana Section

Boyd L. Bonner (M), Gerald J. Hamilton (M).

Kansas City Section

George F. Dixon, Jr. (M).

Metropolitan Section

Eugene S. Corner (M), Carmine A. Deer (M), Anthony De Salvo (A), Eugene T. Doyle (M), Francis C. Dupre (M), John B. Hoglund (M), Christian M. Nielsen (A), William J. Pick (M), Alexander H. Raye (M), Robert A. Wachtler (M), Herbert R. Welsh (J).

Mid-Continent Section

Jackson W. McKinzie (A).

Mid-Michigan Section

Fortunato F. Barberis (M).

Milwaukee Section

Robert A. Bryce (J), Russell C. Gubbins (A), Albert Manna (M), Donald E. Niles (M), Roger L. Schluter (J), Robert M. Ulichny (M).

Mohawk-Hudson Section

William M. Foley (J), Libbus Lewis (A).

Montreal Section

Marcel Dufresne (A), Ronald E. Foster (M), Leo Lacombr (A).

New England Section

Harvey G. Clauson, Jr. (A), Hsia-Si Pien (M).

Northern California Section

Raymond P. Bartlett (A), Thurlow S. Culley, Jr. (A), Roy A. Deal (J).

Northwest Section

Marvin R. Kuehnoel (A).

Oregon Section

Herbert S. Hutton (A).

Philadelphia Section

Richard O. Bender (M), Ellwood M. Johnson (M).

Pittsburgh Section

William L. Bruckart (M).

St. Louis Section

Laurence M. Goodridge (M).

Southern California Section

Kenneth G. Farrar (M), Henry W. Frazer (M), James M. Gross (A), Charles K. Moore (M), Rowland H. Nowell (J).

Southern New England Section

Louis C. Freeman, Jr. (A), Robert B. Goodman (J), Russell H. McClintock (J), Brayton A. Porter (M), Edward G. Sharp (M).

Depend on EUREKA RADIATORS
for RUGGED ENDURANCE & MAXIMUM COOLING

EUREKA

OVER 30 YEARS OF SPECIALIZATION

For over 30 years, EUREKA Cores and Radiators have served the automotive industry with utmost dependability. Our facilities, equipment, and personnel are available for your needs. We welcome the opportunity of integrating our specialized skills with your needs to help you achieve a well-planned production schedule.

What are your requirements? We can build Radiators to your order in any type, to any size or shape. Send us your blueprints for prompt quotations!

EUREKA RADIATORS AND CORES
for CARS, TRUCKS, TRACTORS and SPECIAL APPLICATIONS.

AUTO RADIATOR Manufacturing Co.
Guaranteed Radiator Cores Since 1915
2901-17 INDIANA AVE. • CHICAGO 16, ILLINOIS

which part should be made of metal powder?

We ask: **How will it be used in the end product of which it will be a component?** What are the loads, tolerances, and shape of the individual part? How will it be lubricated? Are there any special requirements such as hardness and finish? Do the quantities justify tooling costs?

These are the questions that were answered before any decisions were made on the parts shown above —both of which are made of metal powder.

Because Moraine Products can draw upon a wide range of experience with many different mass production processes and their applications to specific problems, our judgment on these questions can be considered sound. When we recommend metal powder, it is because we are convinced, in our own minds, that it is the material and the process best suited for the job the specific part must do.

Moraine Products also produces: Moraine Power Brakes—Delco hydraulic brake fluids, brake assemblies, master cylinders, wheel cylinders, and parts—Moraine friction materials—Moraine-400 and M-100 automotive engine bearings—self-lubricating bearings and porous metal filters—rolled bronze and bi-metal bushings.

Another General Motors Value

Moraine Products
Division of General Motors, Dayton, Ohio

FIGHT VIBRATION WITH VIBRATION

Shaker system for complex motion tests

NEWEST TECHNIQUE in environmental testing is complex motion testing. It comes closest to reproducing actual vibrational environments encountered in operation of missiles, aircraft, vehicles.

An MB Vibration Exciter System designed for such service is one of optimum versatility. It fulfills not only the special needs of *random motion testing*, but virtually any other test specification as well . . . such as sinusoidal motion testing, fatigue testing, automatic cycling, and provisions of MIL-E-5272A.

HEART OF THE SYSTEM—THE EXCITER

The MB Model C-25HB (shown) is rated at 5000 pounds peak force. Its table assembly is unusually stiff to reduce resonances yet weighs only 75 pounds. Axial resonance lies well over 2000 cps operating range.

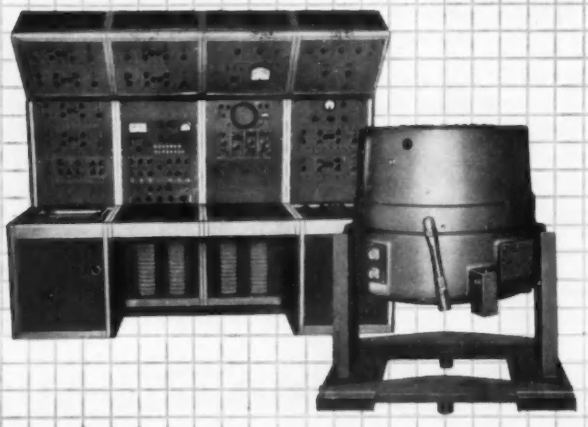
This and other MB Exciters for 200, 1200, 1700, 3500, 7000 and 15,000 pound force ratings faithfully reproduce complex wave input signals because their *frequency response* is *flat*.

MATCHED PERFORMANCE

Other elements of the system are integrated with the exciter's high performance. An electronic *amplifier* fulfills the power demands. A control cabinet houses all necessary *instrumentation* plus frequency and amplitude *controls*. Circuits in a *compensation console* give automatic adjustment so that table acceleration remains proportional to input voltages. A top quality tape recorder for playback of the complex wave patterns may be used.

If you have any questions on vibration testing at all, come to a leading authority on the subject . . . the MB engineering staff.

MB *manufacturing company*
A DIVISION OF TEXTRON INC.
1060 State Street, New Haven 11, Conn.
HEADQUARTERS FOR PRODUCTS TO ISOLATE . . . EXCITE . . . AND MEASURE VIBRATION



New Members Qualified

Continued

Spokane-Intermountain Section

Ralph D. Baker (A).

Texas Gulf Coast Section

Gerald Z. Dubinski, Sr. (J).

Western Michigan Section

Sidney E. Miller (M).

Williamsport Group

George R. Schramm (M).

Outside Section Territory

Glenn E. Dreesen (J), LeRoy H. Ellsworth (A), Sylvan A. Esser (M), Duane E. Hinds (J), M. Perry Hunter, Jr. (J), Vernon R. Kaufman (M), Harry B. Spore (M).

Foreign

Raafat M. El Barrad (J), Egypt; Nabih Elzohiry (M), Egypt; John O. Starling (M), England.

Applications Received

The applications for membership received between August 10, 1956 and September 10, 1956 are listed below.

Atlanta Section

H. Blair Minick, Jr.

Baltimore Section

John Philip Hudak.

British Columbia Section

Thomas A. Ameer-Beg, James M. Lundblom.

Buffalo Section

Chester J. Brian, Jr., Reeve M. Brown, Jr., Warren D. Hils.

Canadian Section

John Maynes Allan, William Vernon Andrews, Donald L. Burrows, John B. Johnston, John A. Reynolds, Robert H. Richmond, Donald Forbes Whitewood, John K. Woodburn.

Central Illinois Section

George W. Carson, Lester Painter, Ralph E. Watt.

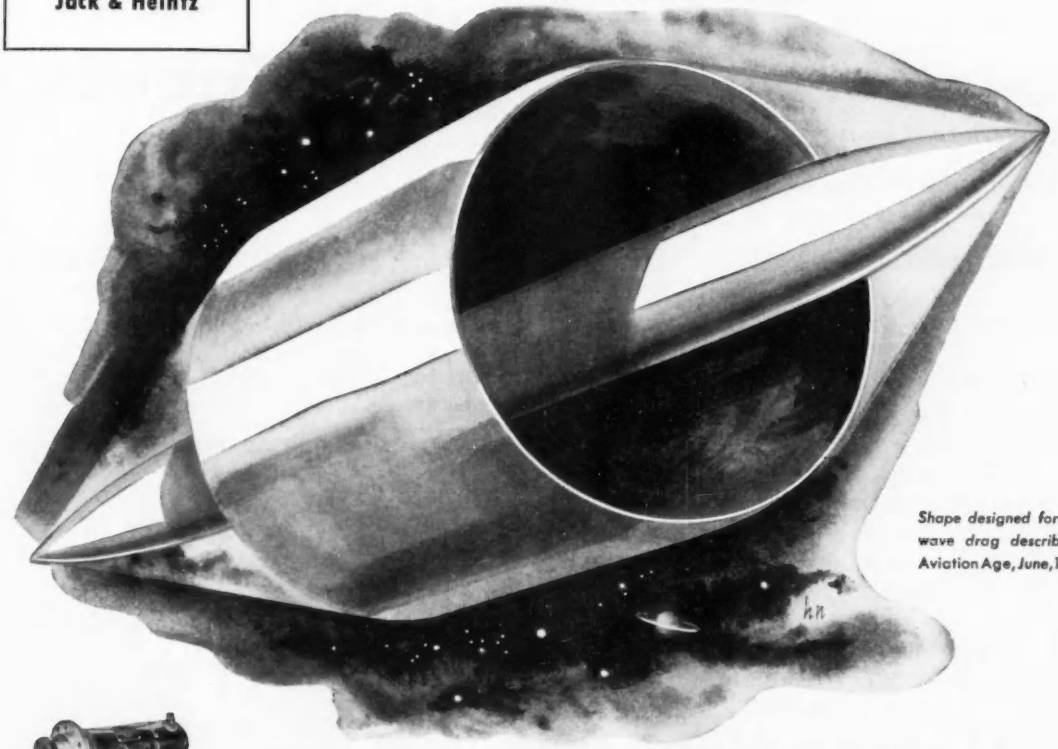
Chicago Section

W. H. Bechman, Donald B. Bickler, Richard L. Blugerman, David L. Chaffin, Donald H. Gautsch, Eugene M. Hoganson, Milton R. Liechty, Edward J. Marcinski, Donald L. Smith, William

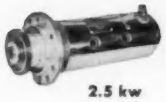
Your tomorrow's electric system waits today at Jack & Heintz

ENVIRONMENT-FREE GENERATORS

J&H oil-cooled machines deliver full-rated output independent of aircraft speeds, ambients, altitudes

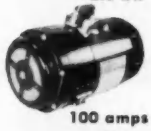


Shape designed for zero wave drag described in Aviation Age, *June, 1956.*

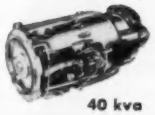


2.5 kw

12.3 kw

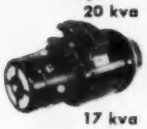


100 amps



40 kva

20 kva



17 kva

Seven years of pioneering development at Jack & Heintz have produced aviation's first "environment-free" generators. Permitting new size-weight-performance concepts for primary and special power systems, the J&H oil-cooled machines outrace the best contemporary units by a wide margin:

- deliver full-rated power regardless of aircraft speeds, ambients, or altitudes
- are smaller than any comparable air-cooled units
- enable lighter and simpler installations
- reduce drag by eliminating need for air ducts

Scheduled for service on advanced aircraft, these J&H generators promise to be the ultimate approach to aircraft electric power.

"Standardized" Approach to Each Advanced Electric System

Regardless of the flight plateau you are sighting, the J&H oil-cooled generators, with the proper heat sink, offer an immediate solution to your electric power needs. This frees you of long lead times to develop new generators. Each advance in flight conditions is met through adjustment of the heat sink.

Confer with J&H specialists. For basic design and performance data, write to Jack & Heintz, Inc., 17638 Broadway, Cleveland 1, Ohio. Export Department: 13 East 40th St., New York 16, N. Y.

Representative J&H Oil-Cooled Generators

J&H Model	30051-004	30052-001	G129-1	31190	31192-003	G280-1
Nominal Rating	2.5 kw	12.3 kw	100 amps	40 kva	20 kva	17 kva
Volts	d-c 3 outputs	a-c, d-c 3 outputs	30	120/208	120/208	120/208
Speed (rpm)	12,000	12,000	8,000	6,000	8,000	12,000
Phase (cps)	—	—	—	3	3	3
Frequency (cps)	—	1,600 400	—	400	400	400
Power Factor (min)	—	—	—	.75	.75	.75
Weight (lb)	30	70	36¼	165*	100*	50
Length (in.)	12.71	14.3	10.57	27.25*	26.0*	12.85
Diameter (in.)	4.5	7.75	6.5	13.0*	9.5*	7.5

*Includes Integrated Constant-Speed Drive

©1956 by Jack & Heintz, Inc.

JACK & HEINTZ AIRCRAFT ELECTRIC EQUIPMENT

Salaries for Engineers

An engineer's salary is determined by more than just his ability

All too often, ability and salary are shackled by lack of opportunity for promotion. For that reason, you'll be interested in Lockheed's diversified expansion program. Forty to fifty major projects are in progress continuously. Commercial and military activities cover virtually all phases of aeronautical endeavor.

The breadth and scope of this program means engineers have exceptional opportunity for promotion at Lockheed—simply because there are more supervisory positions to be filled with so many projects constantly in motion.

If your salary reflects lack of opportunity for promotion, why not look into opportunities presented by Lockheed diversification. It's worth discussing. Write or phone collect, if you possess an engineering degree or actual engineering experience. Address written inquiries to E. W. Des Lauriers or use the brief resumé form below. If you phone, call STanley 7-1241, Extension 6-2134.

To engineers who lack aircraft experience:
Aircraft experience is not necessary to join Lockheed. It's your engineering training and experience that count. Lockheed trains you for aircraft engineering—at full pay.

Advanced education program for engineers:
You can expand your technical knowledge and achieve advanced degrees through a variety of Lockheed-sponsored university programs that cost you little or nothing.

*Positions are open on virtually **all** levels in fields of:*

AERODYNAMICS
FLIGHT TEST ENGINEERING
MATHEMATICAL ANALYSIS
OPERATIONS RESEARCH
STRUCTURES
THERMODYNAMICS
WEIGHT

DESIGN
in controls, electrical, hydraulics, mechanical, power plant and structures areas.

ELECTRONIC SYSTEMS
in communications, countermeasures, fire control, navigation, radar and antenna design.

Lockheed Salary Facts

In the last three-and-a-half years Lockheed engineers have received blanket increases totaling 19%. This is in addition to merit increases granted engineers for individual achievement and promotion.

E. W. Des Lauriers, Dept. SE-16-10
Lockheed Aircraft Corporation, Burbank, California

Dear Sir:
Please send me your brochure detailing life and work at Lockheed.

Name

If you are an engineer, please state your field of engineering

Home street address

City and State Home phone

Lockheed

AIRCRAFT CORPORATION

California Division

BURBANK, CALIFORNIA

PROTECT
the bearings in
your product

with LOW COST
LISLE Magnetic PLUGS

BEFORE

AFTER

It costs so little to replace ordinary drain plugs with Lisle Magnetic Plugs. And there's such a BIG difference. "Before" and "after" views at left show how the powerful magnet in the Lisle Plug pulls abrasive metal out of the lubricant in any housing or sump where precision parts operate in a bath of oil. Removal of this metal reduces wear. Prove it in your product.

Send for Free Sample Lisle Magnetic Plug for testing in your product. State size and type of plug desired.

LISLE Corporation
CLARINDA, IOWA

Applications Received

Continued

Corbin Smith, Jack B. Sparkes, E. F. Tallackson, John P. Tanner, Harry R. Wierzbicki.

Cincinnati Section

John F. Dooley, Jr.

Cleveland Section

Robert J. Farrell, Andrew G. Johnson, Robert Julian Laws, J. D. McMillin, Jr., Chester H. Powers.

Dayton Section

John L. Lass, Louis L. Levy, Charles Warren Wood.

Detroit Section

Donald Adams, James Winston Atkinson, Patrick W. Baker, James A. Barbaria, Theodore E. Beauregard, Jr., Lyle Marvin Blackwell, Jack E. Blalock, Robert Bollens, Frank Borik, Malcolm Brown, Thomas J. Burns, Wesley B. Carlson, David W. Curry, Frank R. Davis, Richard F. Deremer, R. C. Frevik, Clare E. Hellenberg, Henry Wade Hoffman, Donald Gordon Hubbard, Dean R. Irish, Bud E. Lowe, John E. Mahoney, Terry J. Merritt, Donald E. Meyer, Paul E. Milott, Jr., James O'Brien, Maurice W. Ramsby, William H. Ripking, Frederick Snoy, Boris G. Stasuk, Allen Stretlien, Edward F. Thomas, James P. Tomlinson, H. Eugene Weiss.

Hawaii Section

George A. Roth.

Indiana Section

Glenn W. Adamson, Richard R. Booth, Charles E. Bowling, William J. Everett, Jr., Roger W. Gallagher, Allen C. Harra, Robert F. Risku.

Kansas City Section

Don Keith Hereford, John L. Koetting.

Metropolitan Section

Thomas Aun, Eugene M. Beattie, Frederic A. Hicks, Edward C. Jazwa, Jacob A. Kilsan, Dudley Mason, Jr., Martin Miller, Eugene H. Okrent, Carl R. Piserchia, Vincent L. Vaillancourt, George M. C. Wolff.

Mid-Continent Section

Leland Hoppe, Willis C. Schickram.

Mid-Michigan Section

Thomas W. Lamar, Richard W. Robertson, Lindbergh C. Vogt.

Milwaukee Section

Raymond C. Benz, R. M. Bruesewitz,

James H. Carpenter, Jr., James S. Florin, Robert A. Groves, Urban T. Kuechle, Lynn M. Myers, Robert C. Wegner.

Mohawk-Hudson Section

Sanford Charlton Cockrell.

Montreal Section

Raphael Bernstein.

New England Section

William Roger Chase.

Northern California Section

Roland M. Andersen, Folke H. Anderson, Eng Lan Foo.

Northwest Section

Norman E. Arnold, Thomas G. Dennistoun, John E. Isakson, Alfred L. Oppie, Clarence E. Street.

Oregon Section

John A. Payne, Edward F. Vala, Brock B. Wilson.

Philadelphia Section

George M. Bateman, Jr., John S. Richards, John Joseph Spicer, Jr., F. Clark Walton.

Pittsburgh Section

John F. Beck, Peter Hans Donath, George P. Futas, Harry N. Malone, Jr., Edwin H. Spuhler.

St. Louis Section

Paul C. Ford, Fred Kramer, Jr., Lynn M. Norton, Kenneth William Tobin, Clarence F. Westfall, Carl F. Windell.

San Diego Section

Charles W. Alesch, James D. Peterson, William M. Thomas, Clayton Wilbur Vickland.

Southern California Section

James Emley Ahl, Henry E. Banks, Charles Richard Banter, Francis L. Bertolino, Garland O. Goodwin, Duane W. Hendrickson, Alexander B. Hepler, Simeon B. Kramer, Louis L. LeBrun, Jr., Robert A. Lehman, David W. Moore, Duane H. Norton, Buddie W. Proctor, Francis J. Schoelen, Luther U. Shaw, John Robert Stevenson, Hiroshi Tayama, A. V. Walker, Donald H. Watson.

Southern New England Section

Rudolph Hohenberg, Orlo A. Powell, Jr.

Syracuse Section

Richard A. Crocco.

Texas Section

Glenn S. Beidler, Lew Brown Woodall.

Twin City Section

G. M. Carmichael, Carl T. Crawford, Jr.

Washington Section

Douglas A. L. Robson.

Western Michigan Section

Edwin A. McClary.

Wichita Section

S. S. McDonald, Jr.

Outside of Section Territory

Robert Bernstein, Robert C. Butler, Fred Carl, Daniel A. Chase, Roland Alvin Consie, Joseph W. Davis, Thomas C. Goad, Chedo P. Graham, Glen Curtis Hartig, Hubert A. Payne, Hans Albrecht Sack, William R. Shobert, Wilbur W. West.

Foreign

Antonio Barella, Brazil; Bernardo Blaschitz, Venezuela; Willy A. Dahl, Brazil; Charles Evans, Haiti; C. H. Henrard, Belgium; Howard J. Lister, England; T. L. Narasimhan, India; N. N. Narayan Rao, India; V. N. Thampi, India.

SPEED UP ASSEMBLY

of

Mouldings, Nameplates, Medallions, etc.

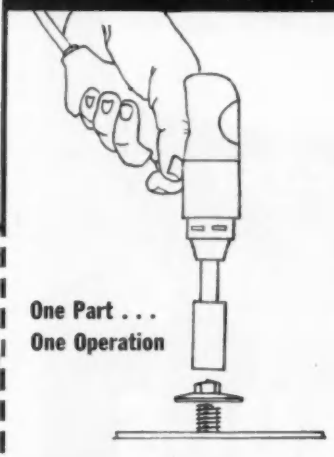
REAL SAVINGS when Washer Type PALNUTS are applied to your mouldings, nameplates, medallions, deck handles, tail and parking lights, instrument mountings, etc. Also real security, due to live spring locking action. Popular thread sizes always in stock. State thread size and washer diameter or clearance around stud or bolt when requesting free samples.

THE PALNUT COMPANY
70 Glen Road, Mountainside, N. J.

Regional sales office
730 West Eight Mile Road, Detroit 20, Michigan
Telephone: Jordan 4-6087

WASHER TYPE PALNUT TRADE MARK® **LOCK NUTS**

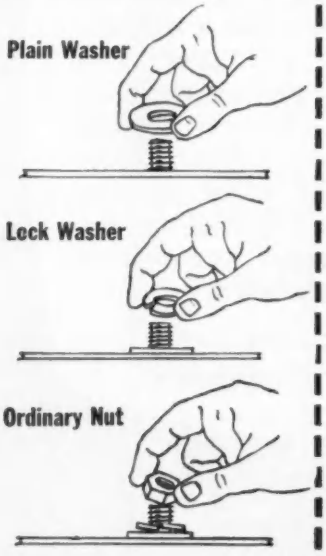
THIS

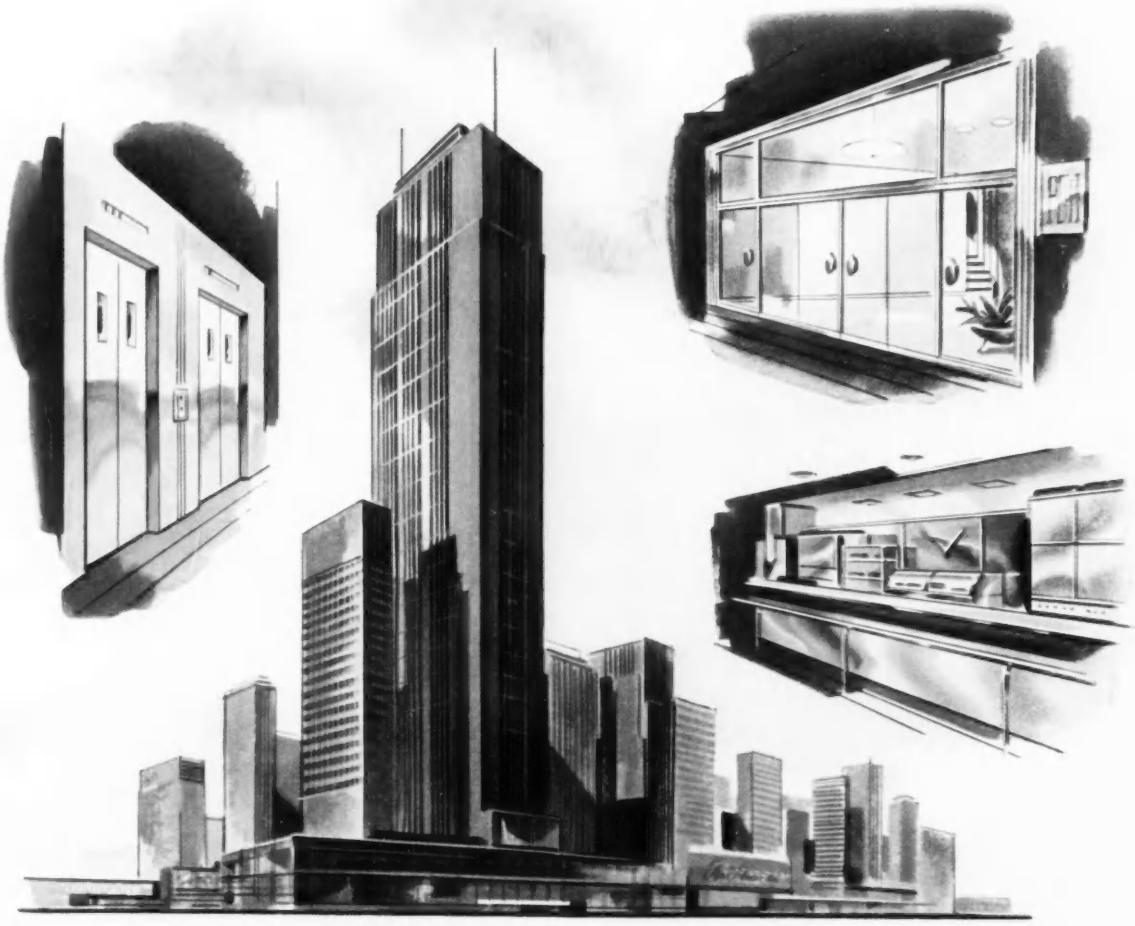


One Part . . .
One Operation

INSTEAD OF THIS

3 Parts . . . 3 Operations





in buildings...

everybody benefits from **stainless steel**

the architect specifies long-lasting Stainless Steel for its strength, its beauty and its economy of maintenance. In heavy use areas and for weather-exposed panels and trim, nothing stands up or keeps its smooth finish like Stainless Steel.

the builder likes working with Stainless Steel. It is easy to install, does not dent, peel or discolor and presents no problem on matching or replacement.

the tenants enjoy living or working in buildings that are bright, clean and attractive because of Stainless Steel.

Mc Louth Stainless Steel

For the product you make today and the product you plan for tomorrow specify McLouth high quality sheet and strip Stainless Steel

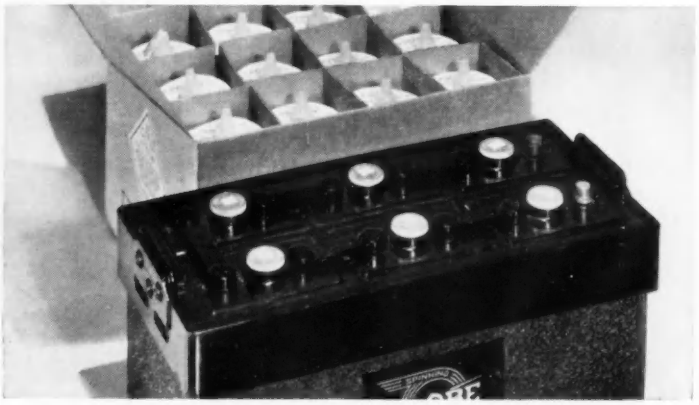
McLouth Steel Corporation **DETROIT, MICHIGAN • MANUFACTURERS OF STAINLESS AND CARBON STEELS**

New GLOBE dry-charged puts battery sales in high gear

SALES STIMULATING . . . EFFICIENT . . . ALL-IN-ONE PACKAGING promotes displays, simplifies stocking. Everything needed — battery, electrolyte and pouring holder — is contained in this single, compact package.

NOW YOU CAN CARRY A COMPLETE INVENTORY, meet the needs of any vehicle on the road. There's no standing loss or need for annoying trickle charge. Globe dry-charged batteries protect your investment because they're fresh until sold.

SAFE AND ECONOMICAL TO SHIP AND HANDLE. *Safe* sturdy plastic bottle has great resistance to shock or impact. Cardboard bottle holder assures positive grip. *Economical* — 15 plastic bottles weigh less than one glass bottle, cost less to ship, take less time to handle. Disposable bottles eliminate returns. No money tied up in returnable or carboy inventory.



FOR ADDED CONVENIENCE WITH LARGER-SIZED BATTERIES and to comply with ICC regulations, certain batteries and electrolyte are shipped in separate cartons. Spinning Power electrolyte is packaged in plastic bottles offering the same benefits as those shown previously. Exact specific gravity and acid purity are assured through Globe's quality controls.

Get Fast, Low-Cost Delivery, Too!

Thirteen of Globe's 16 battery plants,* below, are equipped for dry-charged battery and Spinning Power electrolyte production. Their strategic locations put approximately 40% of the automotive market within a 50¢ per cwt truck load freight zone. For all your battery and electrolyte needs, call on Globe to be sure of top-notch sales and performance.

GLOBE-UNION INC.

MILWAUKEE 1, WISCONSIN

Battery plants at: *HOUSTON, TEXAS *MEMPHIS, TENNESSEE *ATLANTA, GEORGIA *DALLAS, TEXAS *MEDFORD, MASSACHUSETTS *MILWAUKEE, WISCONSIN *MINERAL RIDGE, OHIO *PHILADELPHIA, PENNSYLVANIA *EMPORIA, KANSAS *REIDSVILLE, N. CAROLINA *SAN JOSE, CALIFORNIA *LOUISVILLE, KENTUCKY *HASTINGS-ON-HUDSON, NEW YORK—LOS ANGELES, CALIFORNIA—OREGON CITY, OREGON—AJAX, (ONTARIO) CANADA

If it's Petroleum-powered there's a GLOBE-BUILT BATTERY right from the start!

It's 196X in your engine lab...

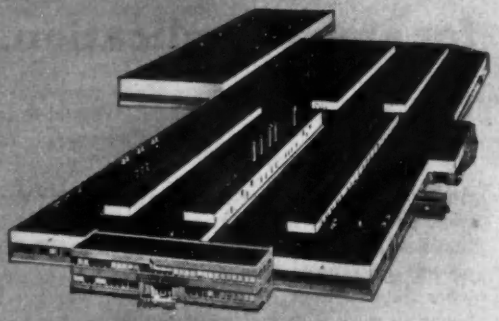
New alloys and improved valve geometry are being developed now at the Valve Division to meet the valve-train requirements of your 196X engines.

For example... Thompson MS-201 is a new service-proved low-nickel alloy developed to be the hardest, most burn-resistant austenitic valve alloy available. MS-201 is the latest in the Thompson-developed family of valve alloys that began with the famous Thompson silcrome steel back in the 1920's.

Another example, 3 types of valve rotation systems to add thousands of extra miles to the valves in your high-performance engines.

Thompson is continually experimenting with new and better valve steels, and valve-train components to keep valve engineering apace of engine developments.

and at our valve plant



Valve Division Thompson Products, Inc.

1455 EAST 185th STREET • CLEVELAND 10, OHIO

MR. ENGINEER . . .

can you use a

HIGHLY ENGINEERED SHAFT

in your product?

US

"Custom-Engineered"

AXLE SHAFTS

for every application...

From bomber to baby-buggy, our 35 years of expert engineering skills can help you improve *your* product performance!

Add to these, our large-scale metal-working facilities, equipped with every modern means to make the *world's finest shafts!* Our new shot peening process guarantees finished shafts *proved up to 5 times tougher* than unpeened shafts! We will be happy to work with you on any problem that turns on a shaft.

Call on U. S. AXLE for every type of Special Shaft

- Drive Shafts
- Idler Shafts
- Gear Shafts
- Clutch Shafts
- Cam Shafts
- Transmission Shafts

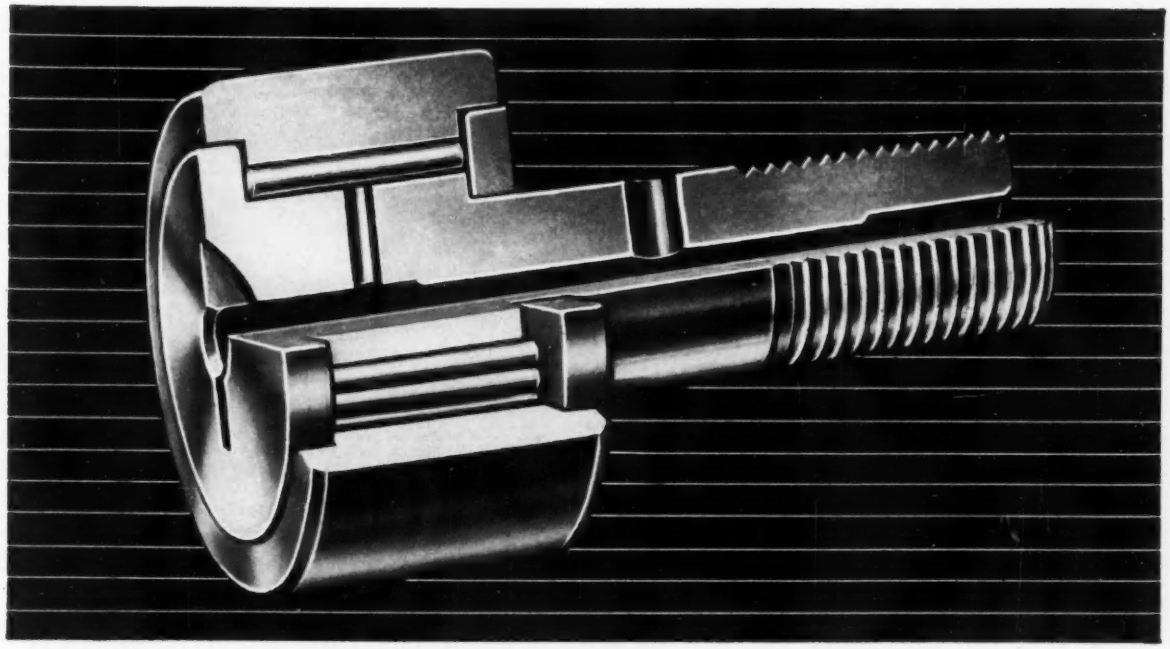
"THE WORLD TURNS ON U. S. AXLES"

This illustrated folder will show you why U. S. AXLE is your best source for precision-made special shafts. Write for your copy today.

For a prompt quotation on a U. S. "Custom-Engineered" Shaft to meet your needs, send us your blueprints and specifications.

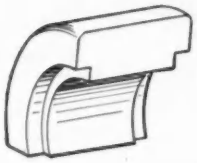
THE US AXLE COMPANY, INC.

Since 1920 • Pottstown, Pennsylvania



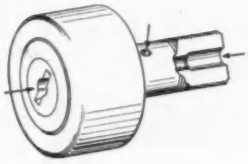
TORRINGTON CAM FOLLOWERS

Give Longer Service . . . Carry High Shock Loads



1. Heavy sectioned outer race of hardened and ground high carbon chrome steel assures uniform distribution of high rolling and shock loads while providing high capacity anti-friction performance.

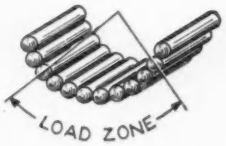
2. Integral stud for cantilever mounting is made of case hardened and ground low carbon nickel molybdenum steel. The tough core provides high strength to withstand high shock loads.

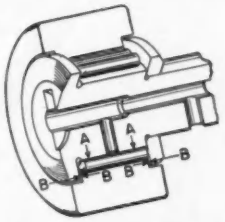


3. Easily relubricated at any one of three points—at either end or through cross hole in stud. Ends accommodate standard drive grease fittings, or may be sealed by the plugs provided.

District Offices and Distributors in Principal Cities of United States and Canada

4. Full complement of small diameter rollers—through-hardened, ground and lapped—for maximum radial load capacity.





5. Raceways precision ground for even load distribution (A) and uniform low end play (B) assure long bearing life.

Torrington Cam Followers are precision made throughout. They are available in sizes from ½" to 2¼" O.D. Special surface finishes such as chrome and cadmium plate or oxide black can be provided.

Our Engineering Department will be glad to work with you in adapting these dependable and efficient Cam Followers to your cam-controlled or track-type equipment. Torrington Cam Followers give better service because they're better made.

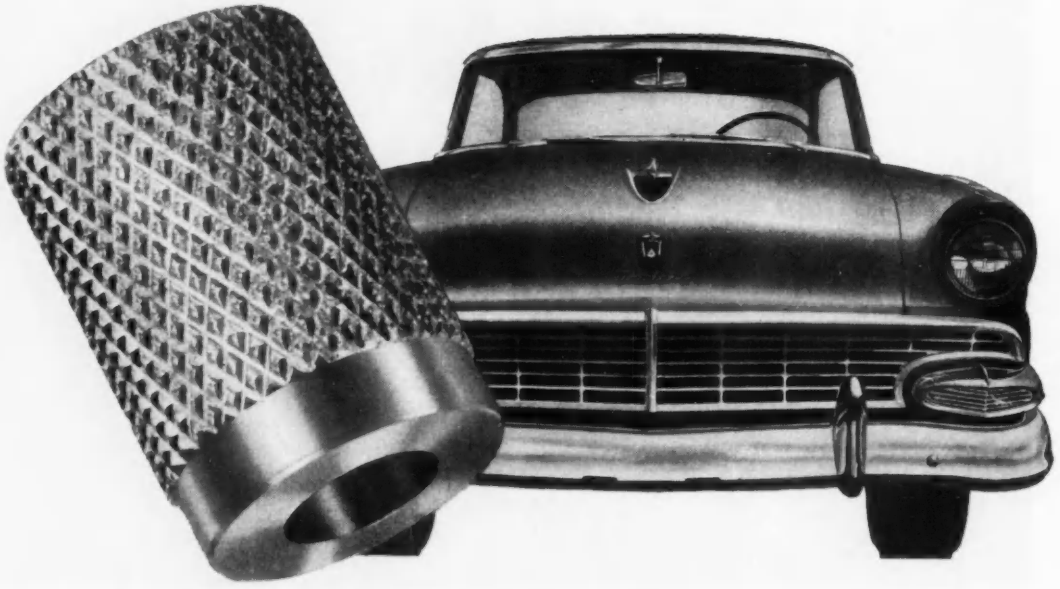
THE TORRINGTON COMPANY

Torrington, Conn. **South Bend 21, Ind.**

TORRINGTON BEARINGS

90th ANNIVERSARY 1866–1956

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers



Ford Motor Co. lowers cost 24% with aluminum windshield wiper knob insert.

Chrysler Corporation adds beauty to the "Forward Look" with aluminum extrusions.

American Motors Corporation lowers cost 14% with lightweight aluminum battery cable.

Hall Lamp Co. improves quality with rustproof headlamp bodies.

LOWER COSTS, MORE BEAUTY, IMPROVED QUALITY

***WITH* Kaiser Aluminum**

Throughout the automotive industry, parts of Kaiser Aluminum are helping add sales appeal . . . reduce manufacturing costs . . . build better automobiles.

Lower cost, more efficient screw machine parts . . . versatile extrusions for decorative trim . . . lightweight economical battery cable . . . rustproof headlamp bodies . . . these are just a few examples.

MAKE OUR AUTOMOTIVE DEVELOPMENT ENGINEERS YOUR "IDEA PARTNERS." Combine your knowledge of your product with our experience in aluminum for maximum improvements and savings.

Call TRinity 3-8000, Kaiser Aluminum & Chemical Sales, Inc., Automotive Development Division, Fisher Bldg., Detroit 2, Michigan; *General Sales Office,* Palmolive Bldg., Chicago 11, Ill.; *Executive Office,* Kaiser Bldg., Oakland 12, California.

See "THE KAISER ALUMINUM HOUR." Alternate Tuesdays, NBC Network. Consult your local TV listing.

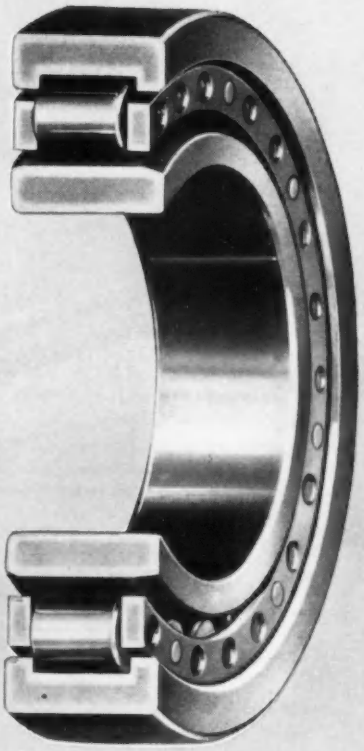
No job too little . . . or none too tough for BOWER STRAIGHT ROLLER BEARINGS

A complete line, a wide range of sizes to fit your specific needs

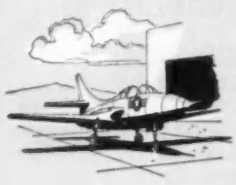
Square pegs weren't made for round holes. And aircraft bearings aren't built for farm equipment, either. That's why Bower designs a complete line of straight roller bearings—a line broad enough to meet any product requirement.

Jet planes break the sound barrier . . . need bearings that'll keep pace. So Bower aircraft bearings are engineered with exactness and precision to tolerances held to millionths of an inch. Bower tractor bearings, on the other hand, are built for ruggedness . . . to take heavy loads and real punishment, day after day, month after month.

Bower Roller Bearings are proved performers *in every field,* for *any* straight roller bearing application. From motors to earthmoving equipment, they're on the job—cutting maintenance and downtime, setting new standards of efficiency and economy. Get details on the *complete* line from a Bower engineer.



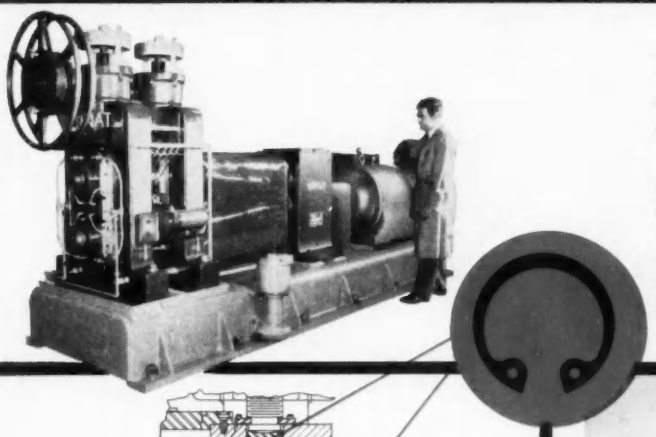
Tapered, Straight and Journal Roller Bearings for every field of transportation and industry



BOWER ROLLER BEARINGS

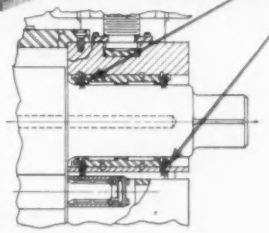
BOWER ROLLER BEARING DIVISION • FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

7-inch Waldes Truarc retaining rings cut costs, speed assembly-disassembly of 2-high/4-high mill

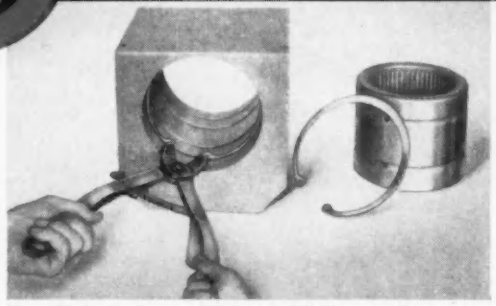


New Model TA-625 2-high/4-high combination rolling mill designed by Stanat Manufacturing Co., Long Island City, N. Y., reduces 2½" ingot to precision-rolled strip as thin as .001".

Waldes Truarc retaining rings help make possible a complete change of work rolls in 20 minutes... solve difficult problems of accuracy control by achieving positive location of bearings to extremely close tolerances. Rings eliminate costly parts and machining, save space, reduce maintenance.



In the assembly illustrated above, 7" Waldes Truarc (Series 5000) retaining rings—three on each roller—are used to position heavy-duty needle bearings in the bearing housing. Smaller rings position bearings in other roller assemblies and retain the shaft of a dual handwheel screwdown. All in all, 18 Waldes Truarc rings are used in the mill. They replace machined shoulders, spacers and lock nuts... eliminate costly threading, other machining operations.



Assembly is simple, even with giant 7" diameter Truarc ring. Special Truarc ratchet pliers grasp the ring securely, ease it into the groove, snap it securely into position. Smaller pliers and various high-speed assembly jigs are available for other rings, permit assembly-disassembly to be performed rapidly even by unskilled labor.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. Quick and easy to assemble and disassemble, they do a better job of holding parts together. Truarc rings are precision-engineered and precision-made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U.S.A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

For precision internal grooving and undercutting... Waldes Truarc Grooving Tool!

WALDES TRUARC® RETAINING RINGS

© 1956 Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N.Y.

Waldes Kohinoor, Inc., 47-16 Austel Place, L.I.C. 1, N.Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
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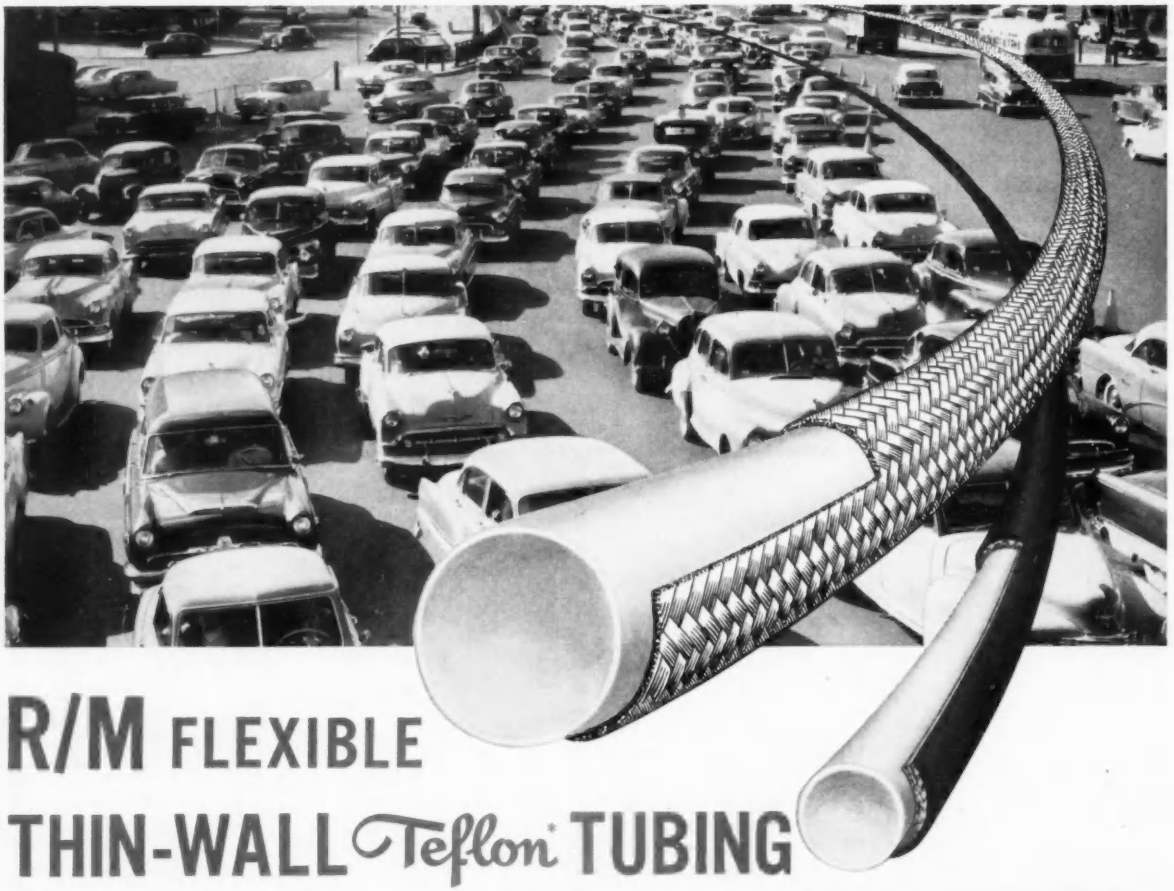
Company .....
Business Address .....
City ..... *Zone* ..... *State* .....

SA 108

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2.574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

NOW AVAILABLE for automotive applications



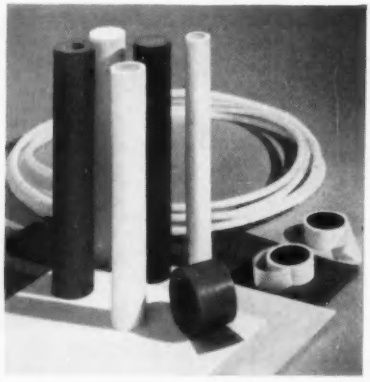
R/M FLEXIBLE THIN-WALL Teflon* TUBING

Working with "Teflon" requires knowledge and skills that only experience can provide. Raybestos-Manhattan's research and testing laboratories have been actively engaged in developing the vast potentials of this remarkable material ever since it first became available.

Now, out of these laboratories comes R/M Flexible Thin-Wall "Teflon" Tubing—stainless steel wire braided or rubber covered—for automotive applications, particularly the cooling of oil in automatic transmissions. This new tubing has great flexibility and does not expand, contract or fatigue. It also has great resistance to high temperatures and corrosive lubricants. Available through leading coupling manufacturers. List of suppliers and complete specifications furnished on request.

Other R/M "Teflon" products for the automotive industry include rods, sheets, tubes and tape; centerless ground rods held to very close tolerances; stress-relieved molded rods and tubes; Raylon —a mechanical grade of "Teflon" with many of the characteristics and properties of virgin "Teflon." *For details, call or write R/M.*

*Du Pont trademark



RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION, MANHEIM, PA.

FACTORIES: Bridgeport, Conn.; Manheim, Pa.; No. Charleston, S.C.; Passaic, N.J.; Neenah, Wis.; Crawfordsville, Ind.; Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Engineered Plastic, Industrial Rubber, and Sintered Metal Products • Packings • Asbestos Textiles • Abrasive and Diamond Wheels
Rubber Covered Equipment • Brake Linings • Brake Blocks • Clutch Facings • Fan Belts • Radiator Hose • Laundry Pads and Covers • Bowling Balls

Safety
Comfort
Economy

MONROE

The Greatest name in Ride Control

MONRO-MATIC SHOCK ABSORBERS — Standard on more makes of cars than any other brand.

MONROE AIR-O-STEER Power steering for air-equipped trucks, buses. Installed in 2 hours.

DIRECT ACTION POWER STEERING — The only truly direct-action Power Steering units available.

MONROE SWAY BARS— Specified as standard equipment on 15 makes of passenger cars.

E-Z RIDE SEATS—Standard on more tractors than all other seats of this type combined.

MOLDED RUBBER PRODUCTS — Precision-built for all automotive and industrial applications.

MONROE AUTO EQUIPMENT COMPANY

Monroe, Michigan—World's Largest Maker of Ride Control Products

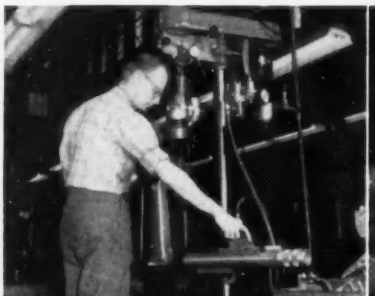
Gardner-Denver... Serving the World's Basic Industries

At this drill press station, four Keller Tool "Airfeedrills," with five-, six- and eight-inch strokes, drill four extra holes in the workpiece as the drill press finishes one hole from above.

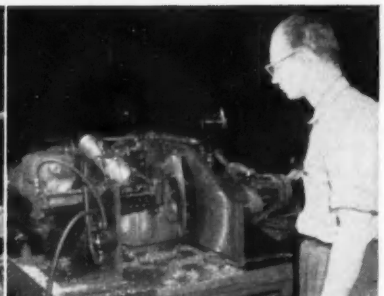
Drills 4 extra holes . . . production time: zero!

Production men have found a new and ingenious way to complete drilling operations with no extra production time. When a workpiece has to be jigged or put in a drill press for some operation, they mount Keller Tool "Airfeedrills"® in position to perform additional drilling, reaming, tapping or facing operations at the same time. The illustrations on this page show how it's done.

Ideal for mounting in multiple units or as single outriggers, Keller Tool "Airfeedrills" and "Airfeedtappers"® perform complete work cycles automatically—at the press of a button. Further details are available in Bulletin 92.



Operator presses a button—and the Keller Tool "Airfeedtapper" provides a free tapped hole while standard machine taps three holes at top of piece.

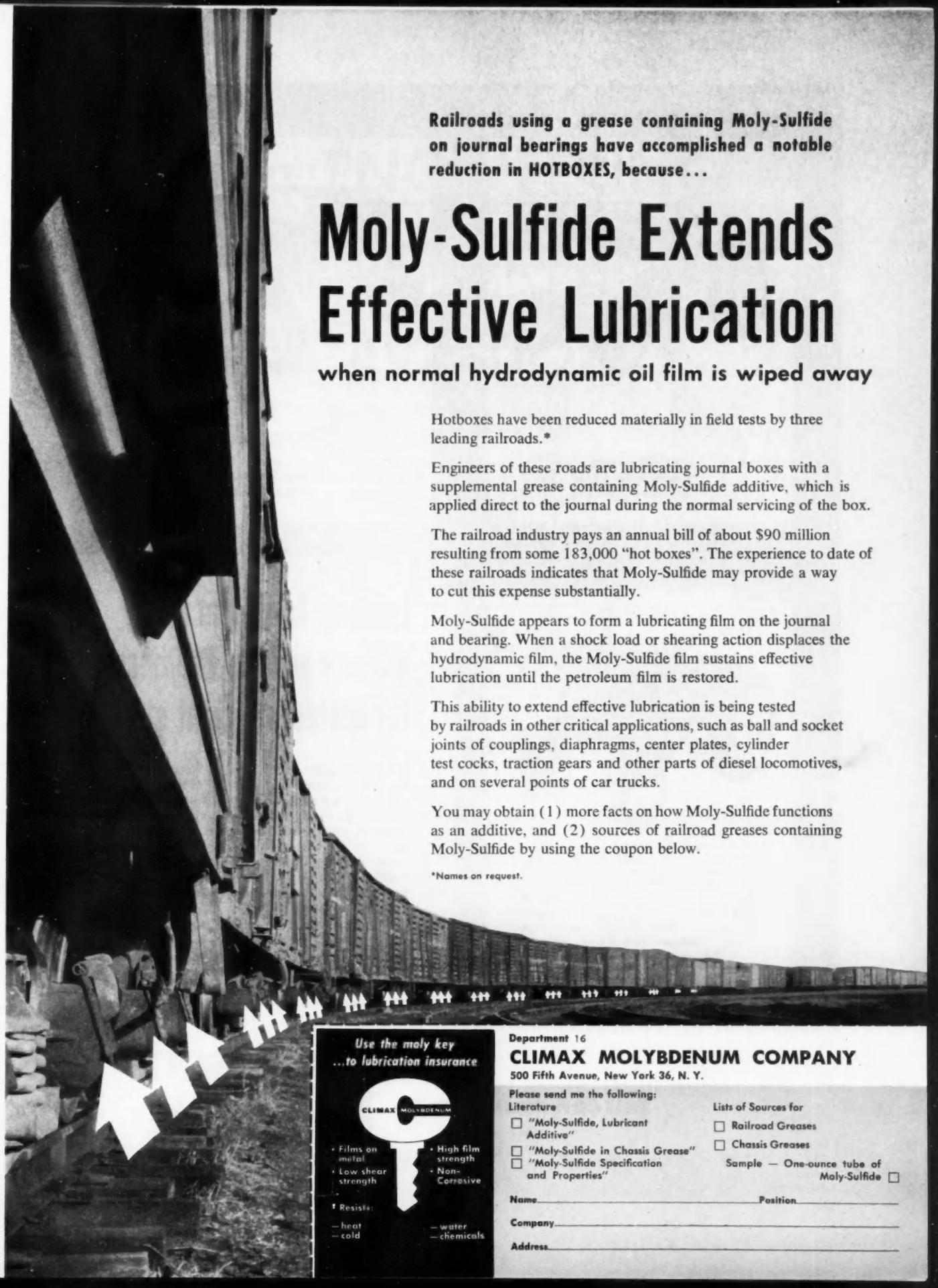


While special multiple head unit drills eight holes in the work, an "Airfeedrill" mounted at rear of fixture step drills a "free" ¼-⅝-inch hole at an odd angle.

GARDNER - DENVER

KELLER TOOL division, Grand Haven, Michigan

THE QUALITY LEADER IN COMPRESSORS, PUMPS, ROCK DRILLS AND AIR TOOLS FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY



Railroads using a grease containing Moly-Sulfide on journal bearings have accomplished a notable reduction in HOTBOXES, because...

Moly-Sulfide Extends Effective Lubrication

when normal hydrodynamic oil film is wiped away

Hotboxes have been reduced materially in field tests by three leading railroads.*

Engineers of these roads are lubricating journal boxes with a supplemental grease containing Moly-Sulfide additive, which is applied direct to the journal during the normal servicing of the box.

The railroad industry pays an annual bill of about $90 million resulting from some 183,000 "hot boxes". The experience to date of these railroads indicates that Moly-Sulfide may provide a way to cut this expense substantially.

Moly-Sulfide appears to form a lubricating film on the journal and bearing. When a shock load or shearing action displaces the hydrodynamic film, the Moly-Sulfide film sustains effective lubrication until the petroleum film is restored.

This ability to extend effective lubrication is being tested by railroads in other critical applications, such as ball and socket joints of couplings, diaphragms, center plates, cylinder test cocks, traction gears and other parts of diesel locomotives, and on several points of car trucks.

You may obtain (1) more facts on how Moly-Sulfide functions as an additive, and (2) sources of railroad greases containing Moly-Sulfide by using the coupon below.

*Names on request.

Use the moly key ...to lubrication insurance

CLIMAX MOLYBDENUM

- Films on metal
- Low shear strength
- High film strength
- Non-Corrosive

Resists:

- heat
- cold
- water
- chemicals

Department 16

CLIMAX MOLYBDENUM COMPANY

500 Fifth Avenue, New York 36, N. Y.

Please send me the following:

Literature

- ☐ "Moly-Sulfide, Lubricant Additive"
- ☐ "Moly-Sulfide in Chassis Grease"
- ☐ "Moly-Sulfide Specification and Properties"

Lists of Sources for

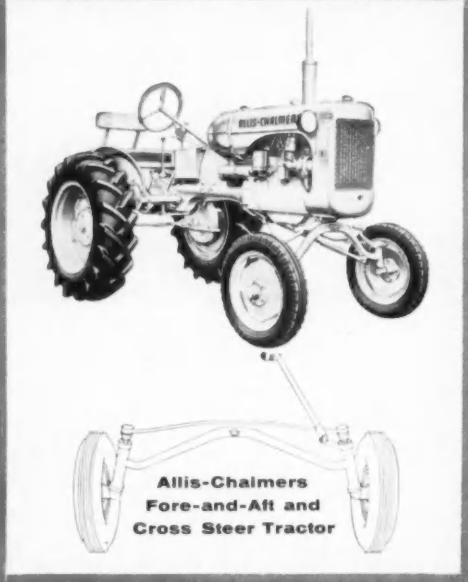
- ☐ Railroad Greases
- ☐ Chassis Greases

Sample — One-ounce tube of Moly-Sulfide ☐

Name_____ Position_____

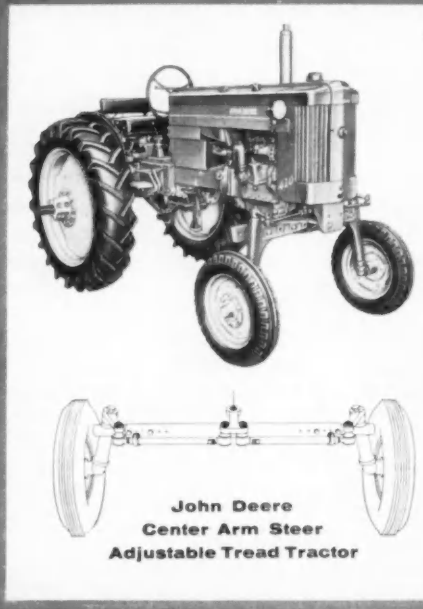
Company_____

Address_____



Allis-Chalmers
Fore-and-Aft and
Cross Steer Tractor

Ford
Adjustable
Tread Tractor



John Deere
Center Arm Steer
Adjustable Tread Tractor

Leading farm tractor makers look to Thompson for better, efficient steering

LEADING farm equipment manufacturers use Thompson Products for their steering linkage requirements. New uses for farm machinery, the farmer's desire for easier steering, new designs, and other important developments . . . all have necessitated better and more complicated steering systems. Thompson engineers have worked hand-in-hand with manufacturers to provide the varied steering linkage necessary for modern farm machinery.

Thompson has an abundance of engineering skills, development facilities and production capacities ready to go to work for you. Why not talk over *your* problems with the people at Thompson. Write or call Michigan Division, Thompson Products, Inc., 7881 Conant Avenue, Detroit.

You can count on

Thompson Products

MICHIGAN DIVISION
DETROIT AND PORTLAND

In ENGINEERING the best OPPORTUNITIES are in AVIATION

In AVIATION the best OPPORTUNITIES are at TEMCO

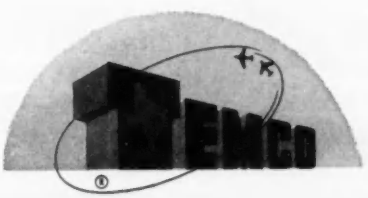
DYNAMICS — Flutter and Vibration Analysis

DESIGNER — Landing Gear, Hydraulics, Power Plant and Airframe

TEST ENGINEERS — Structural, Servo

ENGINEERS — Electronics, Environmental, Materials & Processes, Structures, Structural Analysis & Design, Aerodynamics, Material Review, Liaison, Loftsman

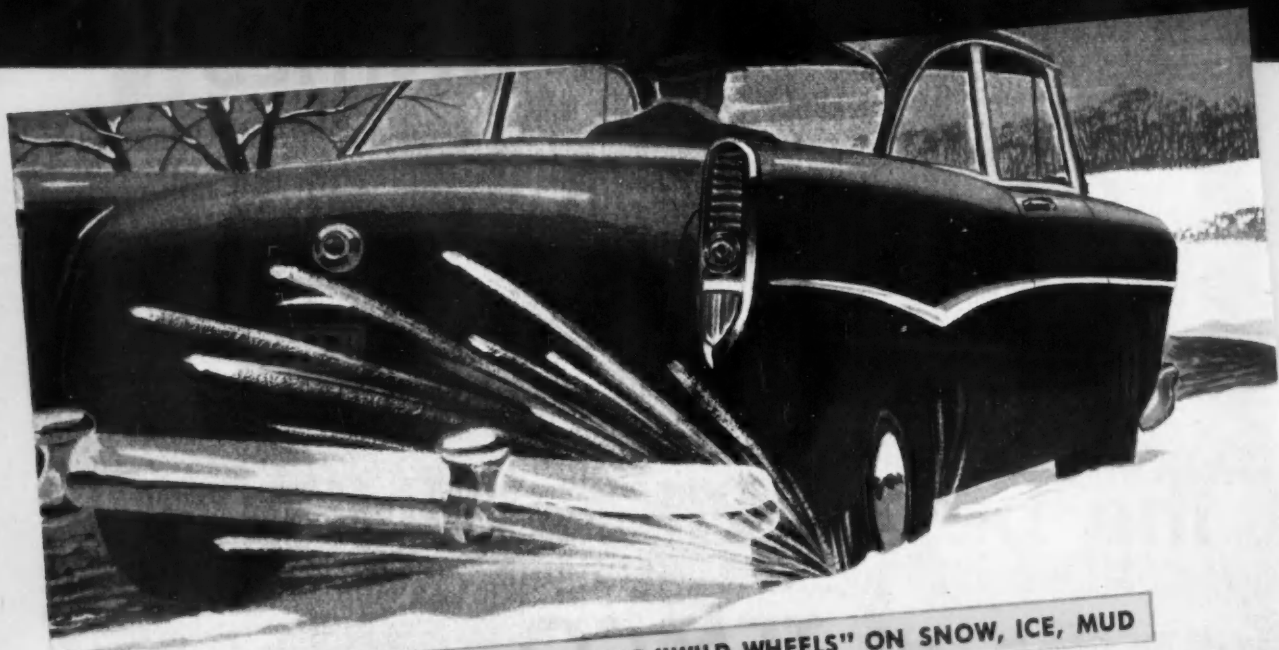
Write: J. W. Russell, Engineering Personnel, Dept. 170-E, Temco Aircraft Corp., Box 6191, Dallas, Texas



AIRCRAFT CORPORATION • DALLAS

SPICER ENDS

Spicer *Thornton POWR-LOK* Keeps Power



SPICER THORNTON POWR-LOK CONTROLS "WILD WHEELS" ON SNOW, ICE, MUD

SPICER THORNTON POWR-LOK CONTROLS "WILD WHEELS" ON ROUGH, BUMPY ROADS

DANA CORPORATION · TOLEDO 1, OHIO

"WILD WHEELS!"

Geared to BOTH Driving Wheels!

THE Thornton POWR-LOK principle is another in the ever-growing list of safety- and power-transmission innovations developed by Dana engineers and Dana resources. It is a new concept of controlled driving-wheel power . . . the most revolutionary rear axle design in volume production since the invention of the differential itself!

The Thornton POWR-LOK Differential in Spicer Axles now makes possible the automatic delivery of controlled torque to BOTH driving wheels under all tractive conditions, and ends "wild wheels" often occurring in ordinary axles.

No more "wild wheels" that spin uselessly in mud, ice, sand or snow. The Thornton POWR-LOK Differential enables the wheel with the *better* traction to apply the *major* driving force to the road, thereby enabling the vehicle to move.

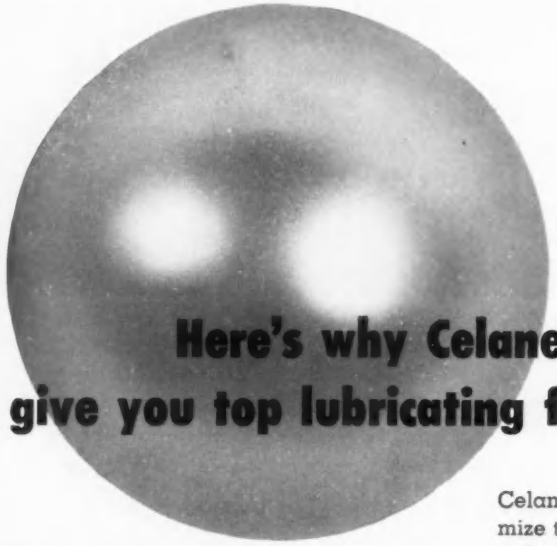
No more "wild wheels" that spin at high speed when bounced into the air by bumps or holes and then come down with sudden stoppage, causing dangerous car swerve or destructive tire scuffing.

The Spicer Thornton POWR-LOK keeps delivering safe, controlled torque to BOTH wheels at all times, adjusting itself instantly to varying road conditions, and assuring steady propelling action to the vehicle.

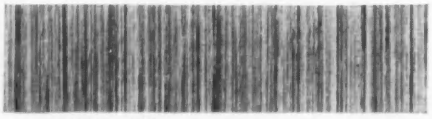
Write for brochure illustrating and describing the efficiency and safety aspects of the new Thornton POWR-LOK Differential as now offered exclusively in Spicer Axles. Available for passenger cars, and light and medium-duty commercial vehicles.

Spicer

SPICER PRODUCTS: TRANSMISSIONS • UNIVERSAL JOINTS • PROPELLER SHAFTS • AXLES • TORQUE CONVERTERS • GEAR BOXES • POWER TAKE-OFFS
POWER TAKE-OFF JOINTS • RAIL CAR DRIVES • RAILWAY GENERATOR DRIVES • STAMPINGS • SPICER and AUBURN CLUTCHES • PARISH FRAMES • SPICER FRAMES



Here's why Celanese fire-resistant CELLULUBES give you top lubricating features



UNUSED PATH

PHOSPHATE ESTER

PETROLEUM OIL

PHOSPHATE ESTER BASE

WATER-GLYCOL BASE

Photomicrographs of the surface of ball path of bearing operated in four hydraulic fluids: petroleum oil, phosphate ester, phosphate ester base, and water-glycol base. Fluids were evaluated on a transfer test machine where angular contact bearings were operated to point of failure. Of the combustion resistant fluids tested, the straight phosphate ester gave the longest bearing modal life and the related ball path showed the least number of microscopic pits.[1]

Celanese Cellulubes are phosphate ester fluids designed to minimize the hazard of flash fires and explosions inherent in many industrial operations.

CONTAIN NO ADDITIVES

Because they contain no additives, Cellulubes give you excellent lubricating qualities, in addition to built-in fire-resistance. Just check these basic advantages offered by Cellulubes:

- FIRE RESISTANCE—**extremely high auto ignition point (over 1100° F.)**
- LUBRICITY—**excellent; low wear factor**
- GRADED VISCOSITY—**range of 6 controlled viscosities—90, 150, 220, 300, 500, and 1000 (S. U. S. @ 100° F.)**
- STABILITY—**unaffected by heat, wear or oxidants**
- NON-CORROSIVE—**in ferrous or non-ferrous systems**
- NON-FOAMING—**contain no additives; resist hydrolysis**
- LONG-LIFE—**chemically and physically stable**
- MINIMUM MAINTENANCE—**no viscosity adjustment required**

As air cylinder lubricants in compressed air systems, Cellulubes prevent the formation of excessive carbon deposits—the major cause of compressor fires. As hydraulic fluids, they reduce the danger of fires due to line breaks or other failures.

If you would like to evaluate Cellulubes in your own operation, use coupon below to order working samples and complete use data.

[1] From a report in *Lubrication Engineering*, July-Aug., 1956, entitled "A Study of Combustion Resistant Hydraulic Fluids as Ball Bearing Lubricants," by H. V. Cordiano, E. P. Cochran, Jr., and R. J. Wolfe.

Reprints of this article are available from Celanese Chemical Division on request.

EXPORT SALES: Amcel Company, Inc. and Pan Amcel Company, Inc., 180 Madison Avenue, New York 16, N. Y.

Celanese Corporation of America, Chemical Division, Dept. 598-J,
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Please send me working sample and technical bulletin on Cellulube for air compressor service ☐ for hydraulic systems ☐ Send technical representative ☐

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Celanese CHEMICALS

Cellulube® Celanese®

NEW !
the CLARK TransVerter

COMPACT
UNIT
"PACKAGE"
OF

* Torque Converter
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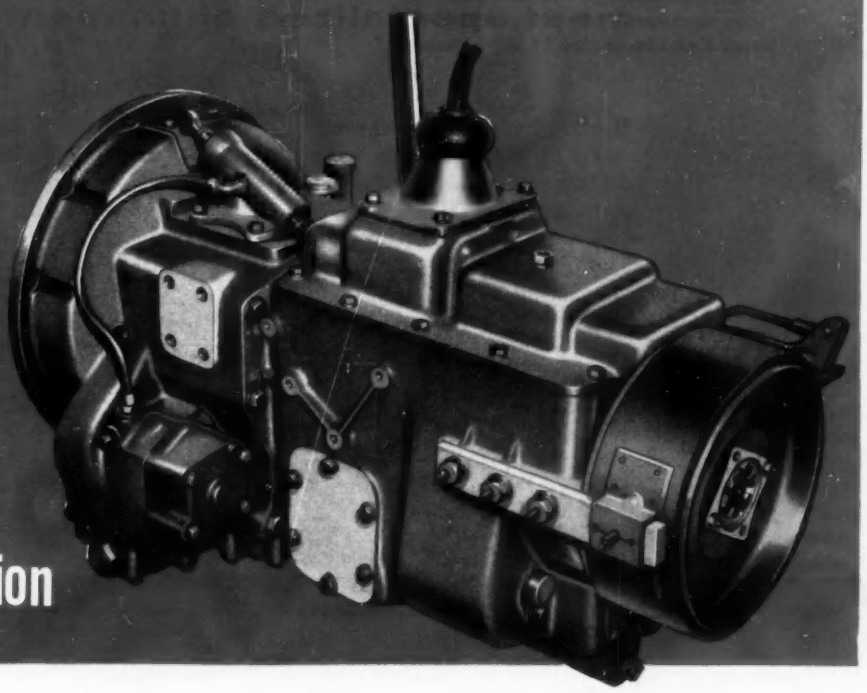
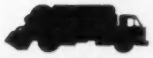


Trucks Operating on delivery schedules

Coaches making frequent stops



Garbage and trash collection

Concrete mixers and similar industrial applications

Materials handling machinery

Many stationary power plants and oil field applications

CLARK EQUIPMENT

Now comes more profitable performance for the operators of stop-and-go vehicles—trucks, both highway and off-the-highway, garbage and trash collectors, concrete mixers, materials handling machines and others: smoother, more economical handling made possible by Clark's new TransVerter.

- **No heavy clutching—reduces driver fatigue. Easy control of hydraulic clutch by shift lever button, floor button, or light pressure clutch pedal**
- **Fine inching control with accelerator**
- **Gear shifting reduced appreciably. Gear changes made quicker**
- **Closely spaced ratios add to ease of shifting resulting in added transmission life**
- **Starts smoothly, no stalling, no lugging**
- **Longer life for entire drive-train—no shock-loading**
- **Less wheel slip—Tires last longer**
- **Clutch adjustment eliminated—Result: savings on costly down time**
- **Excellent accessibility for easy service. Serviceable without special tools by any mechanic familiar with transmissions**
- **Available for OEM or field conversion**

Get the interesting story of these advantages whose economies far offset the moderate additional cost. Send for bulletin.

CLARK EQUIPMENT COMPANY, Transmission Division, Falahee Road, Jackson 5, Michigan
Please send the TransVerter Bulletin

NAME_____

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Westinghouse Electric Corporation

Hydraulic torque converters and power shift transmissions meet specialized equipment needs

Harmonizing engine characteristics with your drive problems is a specialty of Westinghouse hydraulic drives engineering. The result is a hydraulic drive that assures maximum *work output* of your equipment, simplifies operator training, and reduces maintenance.

Westinghouse hydraulic drives are currently being used on heavy-duty construction equipment, off-highway trucks, special-purpose military vehicles and oil well servicing rigs.

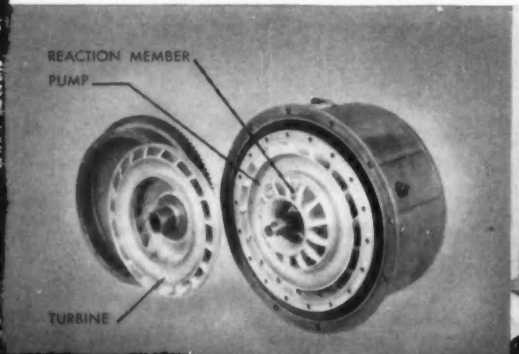
The Westinghouse torque converter is based on the Schneider single-stage system which provides highest efficiency over an extended operating range.

Because Westinghouse manufactures drive components, and not end products, you are assured complete confidence on your advanced design planning. For more information write Westinghouse Electric Corporation, Gearing Division, Pittsburgh 1, Pennsylvania. J-07353

Developed to meet your special needs in earth moving, construction and materials-handling equipment.

(1) Westinghouse single-stage torque converter showing simplicity of basic parts. (2) Matching equipment requirements, Westinghouse engineers analyze advance design planning; result (3), a typical Westinghouse torque converter — power shift transmission package.

1



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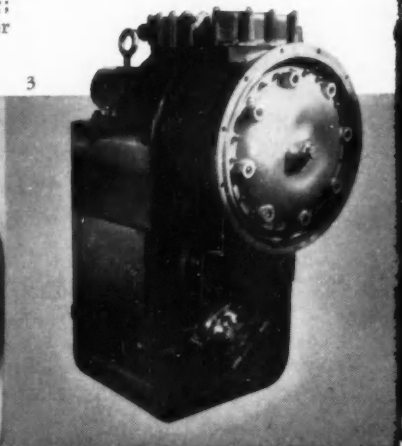

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COVER THE PRESIDENTIAL CAMPAIGN ON CBS TELEVISION AND RADIO!

TUNG-SOL®

VISION-AID HEADLAMPS

5040-S for 6 volt passenger cars
5400-S for 12 volt passenger cars
5440-S for 12 volt trucks and buses

WITH E·Z AIM PLATFORMS

FOR USE WITH ANY APPROVED AIMING DEVICE

The new improved Tung-Sol Vision-Aid Headlamp can be quickly adjusted with any approved aiming device—or can be aimed visually. Three E-Z Aim Platforms, precision-molded on the face of the lens, provide contact points for all the new mechanical aimers. They assure accurate beam adjustment in a matter of minutes—even in broad daylight. These headlamps are fully interchangeable with all sealed beam headlamps of the same voltage.

Car owners benefit from wonderful new safety features of all Vision-Aid Headlamps: The new, more powerful beam gives 80 extra feet of seeing distance down the right side of the road; the filament cap and new lens design improve visibility in rain, fog and snow.

They insure complete satisfaction for car manufacturers, because traditional Tung-Sol quality and nationwide distribution more than meet performance and service requirements.

TUNG-SOL ELECTRIC INC., NEWARK 4, N. J.

Sales Offices: Atlanta, Ga., Columbus, Ohio, Culver City, Calif., Dallas, Texas, Denver, Colo., Detroit, Mich., Irvington, N. J., Melrose Park, Ill., Newark, N. J., Philadelphia, Pa., Seattle, Wash., Canada: Montreal, P.Q.

80 EXTRA FEET OF SAFETY... ACCURATELY AIMED!

Where Dependability is Vital...

HEIM *Unibal* ROD ENDS

at each end of the linkage connecting the bellcrank and the piston wrist pin, operate the all-important air pump in this Technicon-Huxley Chest-Abdomen Respirator. In this application, the Heim Rod Ends eliminate all bind in the reciprocating piston and all noise and play, even after long and constant use.

This respirator, made by Conitech, Chauncey, N. Y., is completely portable and is an improvement over the iron lung, as it leaves the upper and lower extremities of the patient free, permitting sitting-up, exercising of the limbs, and nursing care. Constructed for long-time continuous operation, the power unit is a positive displacement piston mechanism, operated by the Heim Rod Ends, which delivers a volume of about 1100 cu. in. per stroke.

Heim has an informative, illustrated catalog of Unibal Bearings and Rod Ends as well as all other Heim bearings. Send for your copy and use Heim's engineering service for any linkage problem.

THE HEIM COMPANY
FAIRFIELD, CONN.

The single ball principle of the Heim Unibal corrects misalignment, reduces friction, and offers smoother operation and greater freedom of movement in any application.

DU PONT

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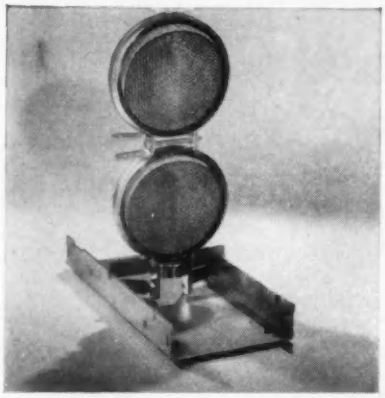
AUTOMOTIVE ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: TEFLON,® LUCITE®

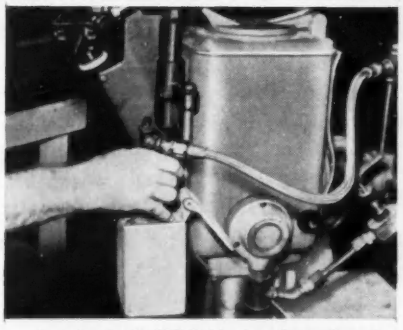


VARI-Flare manufactured by VARI-Products Company, Chicago, Illinois. Reflectors molded by Stimsonite Division of the Elastic Stop Nut Corporation of America, Union, New Jersey.

Reflectors of Du Pont LUCITE® provide safer highway travel

LUCITE acrylic resin helps eliminate "sitting ducks"—cars or trucks stalled on the highway which don't warn oncoming vehicles of their predicament. The portable VARI-Flare pictured above provides the necessary warning in such cases. Its reflectors, injection-molded of Du Pont LUCITE, can be seen for a half mile or more.

LUCITE offers excellent opportunities for the automotive designer. It is available in a wide range of transparent, translucent, and opaque colors and can be molded into almost any size or shape. For more information on how this versatile material can help you with your design problems, clip and mail this coupon.



Hose lined with TEFLON is virtually unaffected by corrosive materials, despite constant flexing, over a broad temperature range. (Manufactured by Resistoflex Corp., Roseland, N. J.)

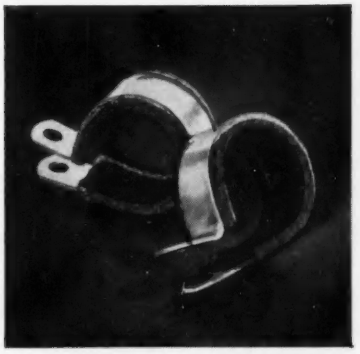
NEED MORE INFORMATION?

For further details that will help you further evaluate these materials for use in your product development program, mail the coupon at the right.

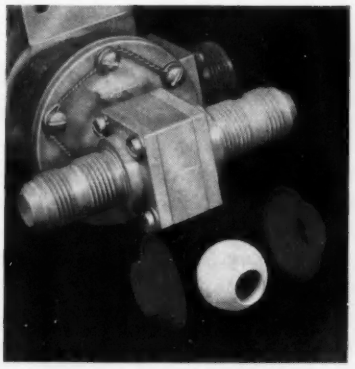
Unusual properties of Du Pont TEFLON® offer many mechanical design advantages

The unusual mechanical and chemical properties of TEFLON tetrafluoroethylene resin make it particularly adaptable to automotive applications. Used as thrust washers in trailer-hinge assemblies, TEFLON has withstood the wear of heavy, swinging doors and weathering for over five years, without replacement. Hose lined with TEFLON retains its flexibility and is unaffected by high-temperature fuels and other corrosive materials. Ball valve seals made of TEFLON demonstrate its ability to retain original size in contact with hydraulic fluids, water, air and other elements which would cause conventional materials to swell. Clamps using a liner impregnated with TEFLON are completely unaffected by all hydraulic fluids, lubricating oils and fuels. Because of the low coefficient of friction of TEFLON, these clamps can allow for rotational or longitudinal movement. These examples are typical of the success that can be achieved when using TEFLON in mechanical applications.

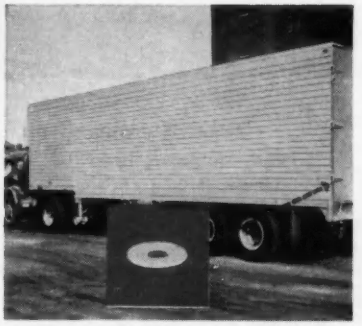
Basic property and application data on TEFLON tetrafluoroethylene resin is available to you. It will help you to evaluate this material for your own use. Simply clip and mail this coupon.



"Joclamps," initially developed for the aircraft industry, use liners impregnated with TEFLON for excellent chemical stability and age resistance, over a wide temperature range. Will not char or carbonize. In this and other applications, the self-lubricating characteristics of TEFLON assume importance. (Manufactured by the Joclin Manufacturing Company, North Haven, Connecticut.)



Molded ball seals of TEFLON provide tight, long-lasting seals for valves handling hydraulic fluids, water or air. (Manufactured by the Sparta Manufacturing Company, Dover, Ohio.)



Thrust washers used in trailer-door hinges are made of TEFLON. They stand up to rugged usage and require no lubrication. (Made by Brown Trailers Inc., Spokane, Washington.)

E. I. du Pont de Nemours & Co. (Inc.)
Polychemicals Department, Room 4610, Du Pont Building, Wilmington 98, Delaware

Please send me more information on Du Pont "Teflon" tetrafluoroethylene resin and "Lucite" acrylic resin. I am interested in evaluating this material for_____

NAME_____ TITLE_____

COMPANY_____

STREET ADDRESS_____

CITY_____ STATE_____

TYPE OF BUSINESS_____

A business grows on product acceptance . . . heavy demands for IPC's custom designed packings, oil seals and precision molded products have forced expansion of engineering and manufacturing facilities. Ground breaking ceremonies in Bristol, New Hampshire took place only a few weeks ago and full production in the first unit of these new quarters is expected by late '56.

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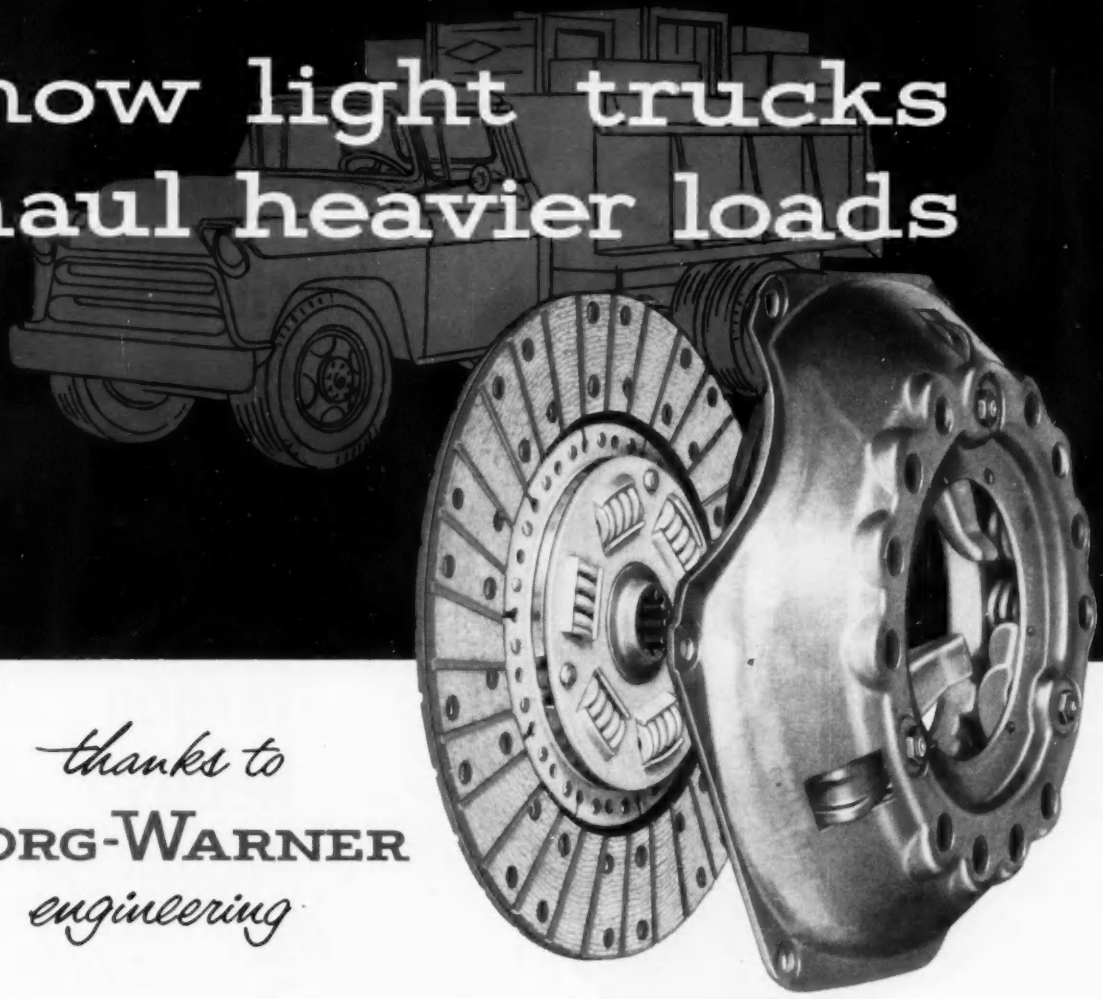
P5

now light trucks haul heavier loads



thanks to

BORG-WARNER

engineering

Time was when light trucks weren't expected to handle anything but light loads. Today the demand is for light trucks with the ability and capacity to handle far heavier loads. But the greater the load, the greater the stress on the clutch. So the problem is to pack more "muscle" into the clutch without increasing its size or weight.

Through advanced design and creative engineering, Borg-Warner's Borg & Beck Division has developed a new three-lever clutch that's actually lighter and shallower than before, yet with up to 20% greater load capacity. Designed for high torque engines, it's smoother and quieter. Its arch type construction means better ventilation. It is self-adjusting, for minimum maintenance. And it's available in 10″, 10.5″ and 11″ sizes for a wide range of applications, both light truck and passenger car.

Precision built and thoroughly tested for balance and uniformity, this new Borg & Beck clutch is another typical example of the "design it better—make it better" thinking that goes into every Borg-Warner product.

Almost every American benefits every day from the products of

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THESE UNITS FORM BORG-WARNER, Executive Offices, 310 S. Michigan Ave., Chicago DIVISIONS: ATKINS SAW • BORG & BECK • BYRON JACKSON • CALUMET STEEL • DETROIT GEAR • FRANKLIN STEEL • HYDRALINE PRODUCTS • INGERSOLL CONDITIONED AIR • INGERSOLL KALAMAZOO • INGERSOLL PRODUCTS • INGERSOLL STEEL • LONG MANUFACTURING • MARBON CHEMICAL • MARVEL-SCHEBLER PRODUCTS • MECHANICS UNIVERSAL JOINT • NORGE • PESCO PRODUCTS • ROCKFORD CLUTCH • SPRING DIVISION • WARNER AUTOMOTIVE PARTS • WARNER GEAR • WOOSTER DIVISION • YORK • SUBSIDIARIES: B-W ACCEPTANCE CORP. • BORG-WARNER INTERNATIONAL • BORG-WARNER, LTD. • BORG-WARNER SERVICE PARTS • BYRON JACKSON OF CANADA, LTD. • EBERHARDT-DENVER CO. • LONG MFG., LTD. • MORSE CHAIN • MORSE CHAIN OF CANADA, LTD. • REFLECTAL CORP. • WARNER GEAR, LTD. • WESTON HYDRAULICS, LTD.

new clutch is adaptable to all torque needs

* Torque capacity of the new Lipe Direct Pressure Clutch can be modified by removing springs in multiples of three. For example: depending on its service, a 15" DP may require its full complement of 27 springs . . . or no more than 24, 21, 18, or 15.

The economies permitted by "de-springing" are obvious. Manufacturers can now carry a smaller stock of assorted clutches without sacrificing flexibility on the assembly line. Fleet Owners will notice significant reductions in maintenance since clutches won't be under- or overloaded.

Five sizes of Lipe's Direct Pressure Clutch — for engines developing from 300 to 1300 ft-lb of torque —now available. Write for complete details.

Manufacturers of Automotive Clutches & Machine Tools

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THE ONE-MAN-GANG
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MECHANICS Roller Bearing UNIVERSAL JOINTS excell for both main drives and controls — in all kinds of material handling trucks. Have transmission flanges for any type of brake drum Easy to service — MECHANICS Close-Coupled UNIVERSAL JOINTS transmit more power — in less space — at greater angles than any other joints. Let MECHANICS engineers help give *your* machines competitive advantages.

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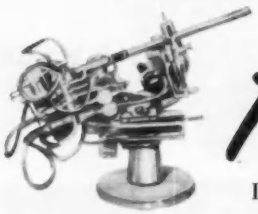
A LOW-POROSITY, WEAR-RESISTANT ALUMINUM OXIDE COATING

In LINDE's Flame-Plating process, particles of the coating material are literally *blasted* onto the workpiece.



Flame-Plating by Linde Trade-Mark

LINDE's Flame-Plating method of coating metal surfaces now provides extra wear resistance for parts subject to extremely hard wear and high temperatures. This new high-purity aluminum oxide coating, blasted from the Flame-Plating gun, builds up on the workpiece in desired thicknesses from .002 to .040 inch. With a porosity of *less than 1 per cent*, the aluminum oxide coating can be used at temperatures up to 1750 degrees F.

The hardness of aluminum oxide coatings, Flame-Plated by LINDE, ranges from 1000 to 1200 VPN. Metallurgical properties of the base metal are not modified by the Flame-Plating process because the part being plated always remains at a temperature of 400° F. or below. The bond between coating and base metal is exceptionally strong with aluminum. Aluminum oxide coatings can be used in as-coated condition (approximately 120 microinches rms), or finished to better than 1 microinch rms.

Flame-Plated coatings of aluminum oxide provide resistance to wear, and to chemical action in high temperature applications. Applications are found in thrust bearings, pump plungers, thermocouple tubes, gas turbines, guided missiles, and other devices. Either aluminum oxide or tungsten carbide can be Flame-Plated on most metals. If you have a special wear problem, LINDE's Flame-Plating Department will gladly help you to reach a solution. Write to "Flame-Plating Department SA-10."

LINDE AIR PRODUCTS COMPANY

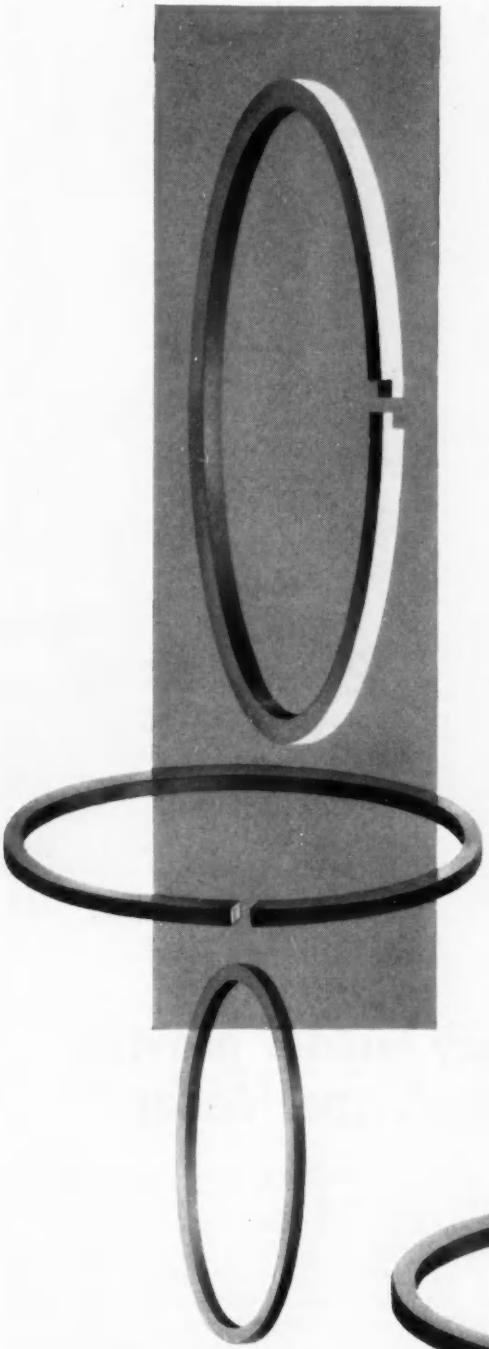
A Division of Union Carbide and Carbon Corporation

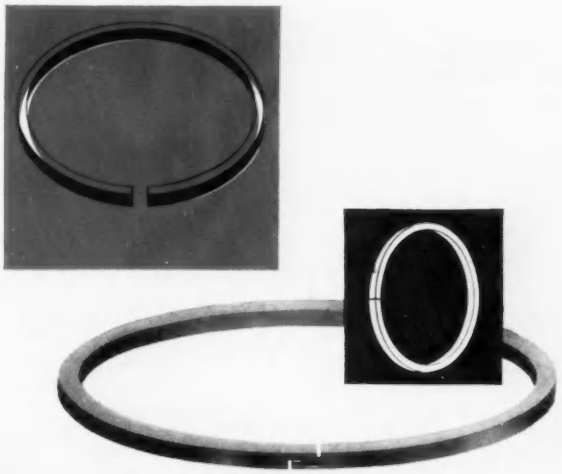
30 East 42nd Street UCC New York 17, New York

In Canada: Linde Air Products Company, Division of Union Carbide Canada Limited, Toronto

The term "Linde" is a registered trade-mark of Union Carbide and Carbon Corporation.

Flame-Plating by Linde





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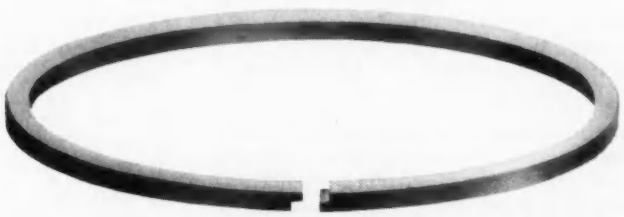
Sealed Power made the FIRST sealing rings, for use in military tanks, 18 years ago.

Sealed Power has made the MOST sealing rings—over a hundred million of them. That's well over half of all the sealing rings ever manufactured by anybody!

By virtue of this tremendous experience Sealed Power is your best source when you need sealing rings for automatic transmissions and power steering units. When you have any kind of a sealing ring problem, bring it right to Sealing Ring Headquarters—to Sealed Power!



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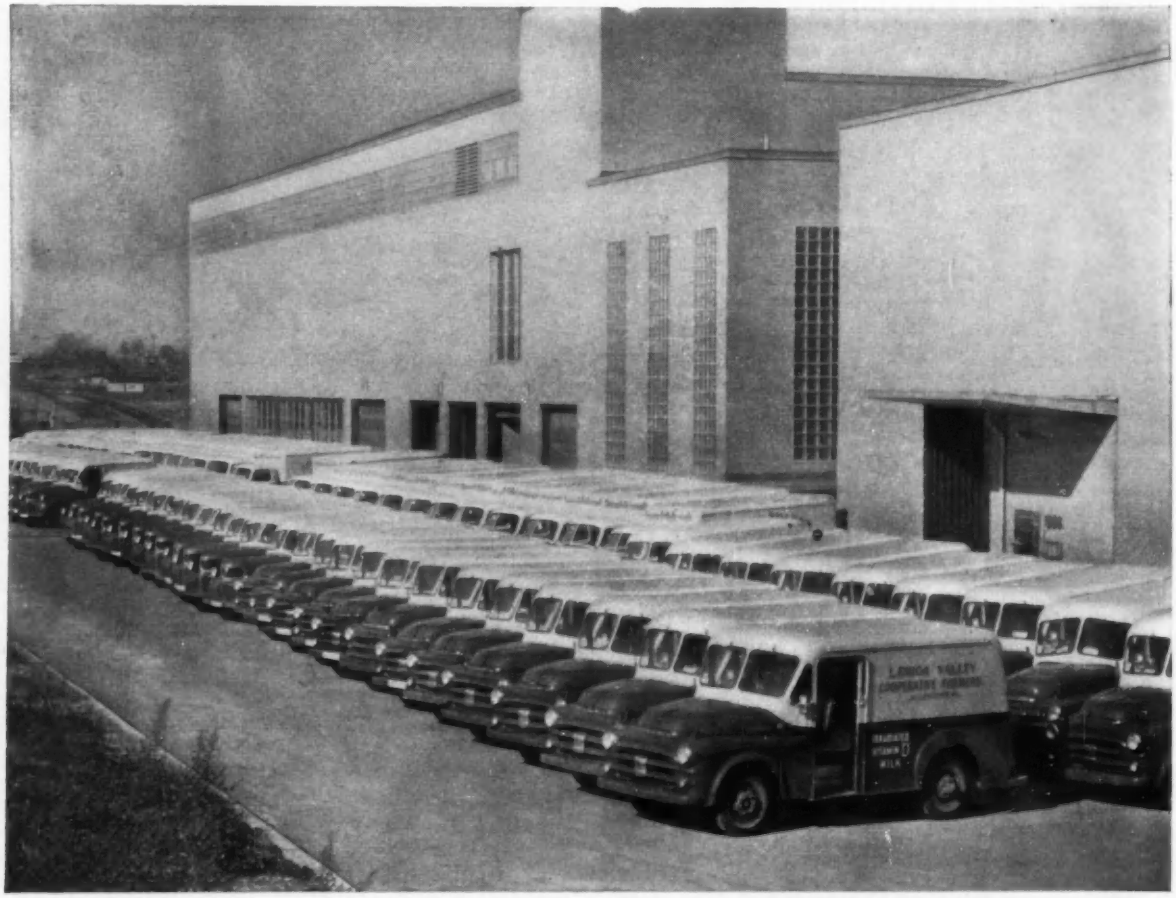


A great fleet . . . with bodies able to take day-in day-out dairy route punishment. These bodies withstand the strains of stop-and-go driving, attacks of weather, water and general hard use, yet maintenance is minimum. Because they are designed to utilize the properties combined in high strength low alloy steels containing nickel. Built by Boyertown Auto Body Works, Inc., Boyertown, Penna.

Nickel alloy steel helps body builder provide more strength...per pound...per dollar

Light, strong and corrosion-resisting...the truck bodies for this fleet were designed by Boyertown Auto Body Works, Inc., to utilize properties of a money-saving structural material – *high strength low alloy nickel-copper steel.*

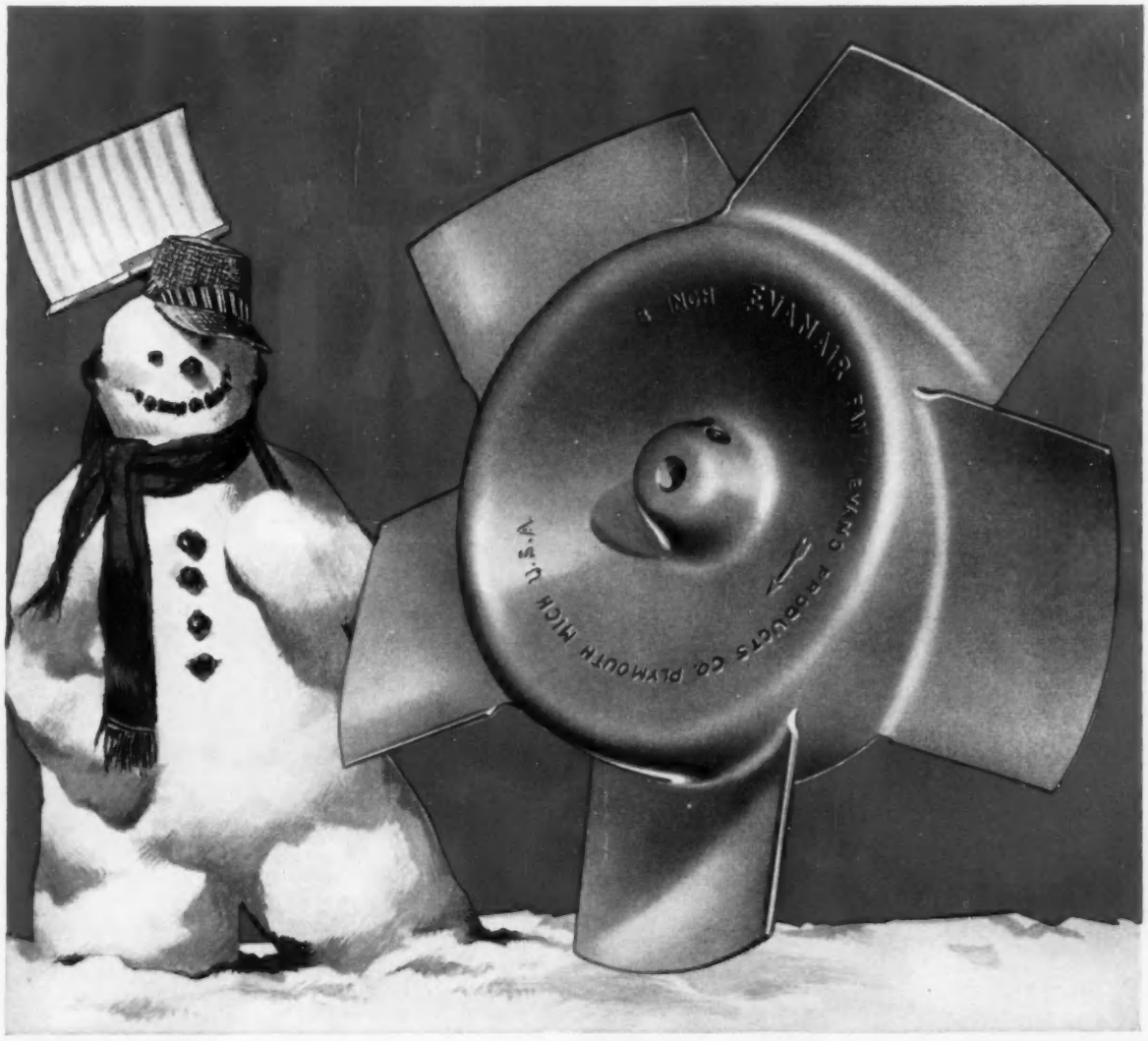
As-rolled, without heat-treatment, steels of this type show a 50,000 psi minimum yield point, or about 1½ times that of plain carbon structural steel. Sheet gauges may be cold formed into structural panels that cut weight substantially, without sacrifice of strength or safety.

In addition, high strength low alloy nickel-copper steels offer 4 to 6 times greater resistance to atmospheric corrosion than do carbon steels. Thus, they retain a high degree of original strength. They also offer superior resistance to shock, battering and abrasion. As a result, use of these nickel steels extends the life of fabricated structures.

Moreover, high strength low alloy nickel-copper steels readily respond to fabrication processes, including welding. These steels, containing nickel along with other alloying elements, are marketed under a variety of trade-names by leading steel companies.

Get full details in "Nickel-Copper High Strength Low Alloy Steels" . . . *your manual* for the asking. It discusses design factors that cut weight safely, explains why these alloy steels resist atmospheric and other types of corrosion, describes behavior in fabrication, and illustrates scores of applications. Write for this manual now.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N. Y.



A Fan for COLD Weather?

Use a fan in winter? Certainly, when it has built around it the best heating unit you can install in your trucks!

Evans truck heaters have this one-piece alloy fan. It never loses its balance, won't chip, crack or bend, has no parts to work loose. It weighs less than half as much as ordinary fans, yet it delivers more volume with less vibration and motor wear.

This exclusive fan, which was designed and developed right in our own laboratory, is typical of the heavy-duty components used in Evans Heaters – heaters which are custom-built to your truck requirements. The best materials and the best construction combine to give you a heater unit that matches your trucks in quality, performance, long life . . . and every Evans Heater is backed with a parts "repair or replace" warranty good for a full year or 50,000 miles, whichever occurs first.

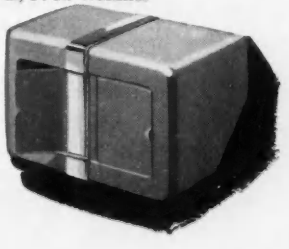
A complete heater catalog is yours for the asking. If you have a truck heater problem, our engineers will be glad to help you solve it. There's no charge for this service. Write Evans Products Company, Dept. Z-10, Plymouth, Michigan.

Regional Representatives: Cleveland, Frank A. Chase . . . Chicago, R. A. Lennox Co., Inc. . . . Detroit, Chas. F. Murray Sales Co. . . . Allentown, Pa., P. R. Weidner

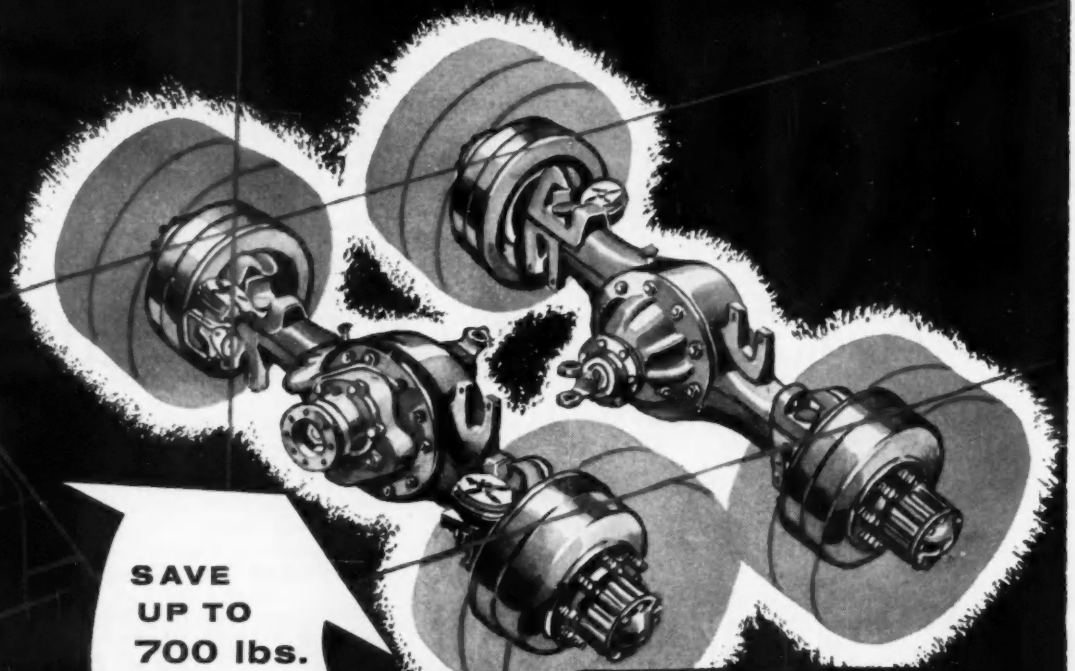
EVANS TRUCK AND BUS HEATERS AND VENTILATING SYSTEMS

EVANS PRODUCTS COMPANY also produces: railroad loading equipment; bicycles and velocipedes; Evaneer fir plywood; Evanite battery separators and Evanite hardboard.

EVANS



UP TO AN extra OF PAYLOAD



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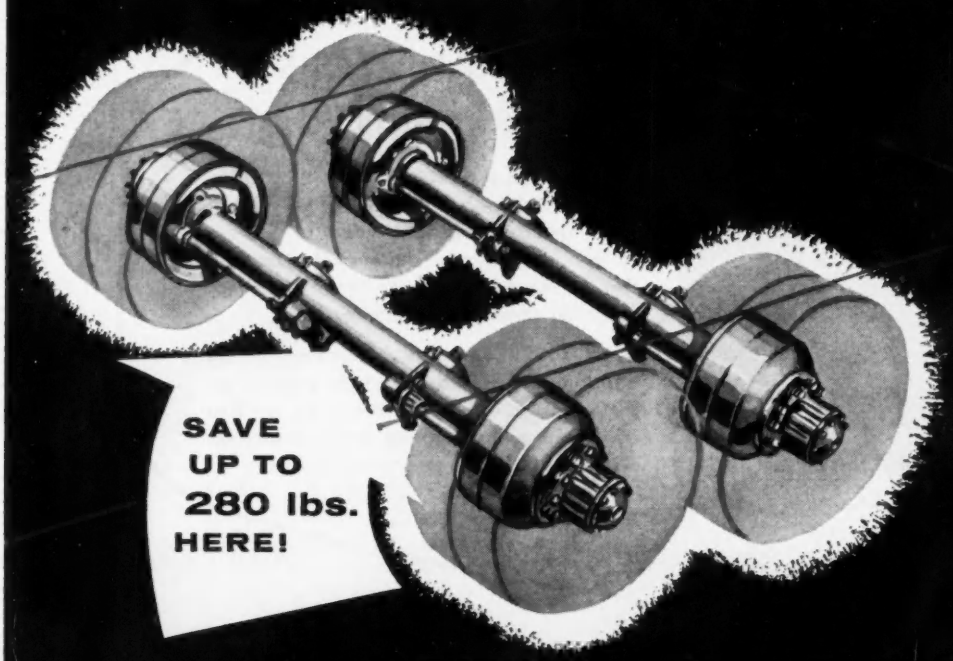
WORLD'S LARGEST MANUFACTURER OF AXLES FOR TRUCKS, BUSSES AND TRAILERS

980 lbs.
EVERY TRIP



Almost 1,000 lbs. of extra payload every mile for the life of the vehicle when you use the combination of new, lightweight

TDA® Tandem Driving and Trailer Axles!

Used together, Timken-Detroit lightweight tandem driving and trailer axles weigh almost 1/2 ton less than other axles of the same capacity. This means up to 980 extra pounds of *bonus* payload every trip.* For complete information contact your vehicle dealer or branch today.

*Where 36,000 lb. tandem axle loading is permissible.

New equipment, expanded departments, added technical personnel and increased productivity all help to make Long your ideal "production partner."

But you'll discover Long's real plus factors in our management-engineering team. Its talent for creating high quality products with economical design and volume manufacturing advantages is your biggest profit potential.

LONG-BUILT TRACTOR RADIATORS GIVE TOP PERFORMANCE

Tractor engines need specialized cooling to do the best possible job. Leading tractor manufacturers specify Long-built radiators because they are rugged and dependable; *because they are engineered for the best performance under the severest field requirements.*

Since 1903 Long has been engineering and building high quality heat exchangers for industry. Whatever the type of fuel used, your engine cooling can be improved. Ask us for help on *your* problem.

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THE STANDARD OF QUALITY AND PERFORMANCE SINCE 1903

Important Facts About The New Ermeto® Hydraulic Tube Fittings

► **The Weatherhead Company, Fort Wayne Division, Fort Wayne, Indiana, announces a new type 7000 Series ERMETO high-pressure S.A.E. flareless, straight-thread hydraulic tube fitting. Designed to accommodate minimum close coupling. Treated with "WEATHERCOTE" finish to resist nonflammable hydraulic fluids as well as petroleum base fluids.**

THE new 7000 Series Ermeto line meets the new standards as set by the S.A.E. This new fitting is an adaptation of the well-known Weatherhead Ermeto design used extensively in military, construction and industrial equipment for hydraulic and pneumatic systems.

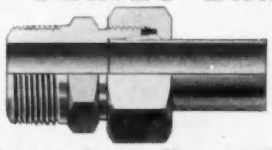
(A) Designed to accommodate minimum close coupling. Installation can be made in seconds with standard bench tools. The cutting and bowing action of the sleeve assures an unyielding leakproof seal . . . a joint that can be disassembled and reassembled time and time again.

(B) New phosphate finish (identified as "Weathercote" is resistant to nonflammable hydraulic fluids as well as petroleum base fluids. Even without lubrication, "Weathercote" finish reduces torquing to preset or reset sleeve as compared to cadmium plating.

(C) Designed for use with the new S.A.E. "0" ring boss, this new line withstands higher operating pressures without the use of back-up rings; results in less "0" ring distortion, longer "0" ring life. The new type "0" ring seal is also designed for air application and tested to operate at temperatures from —65° F. to 212° F.

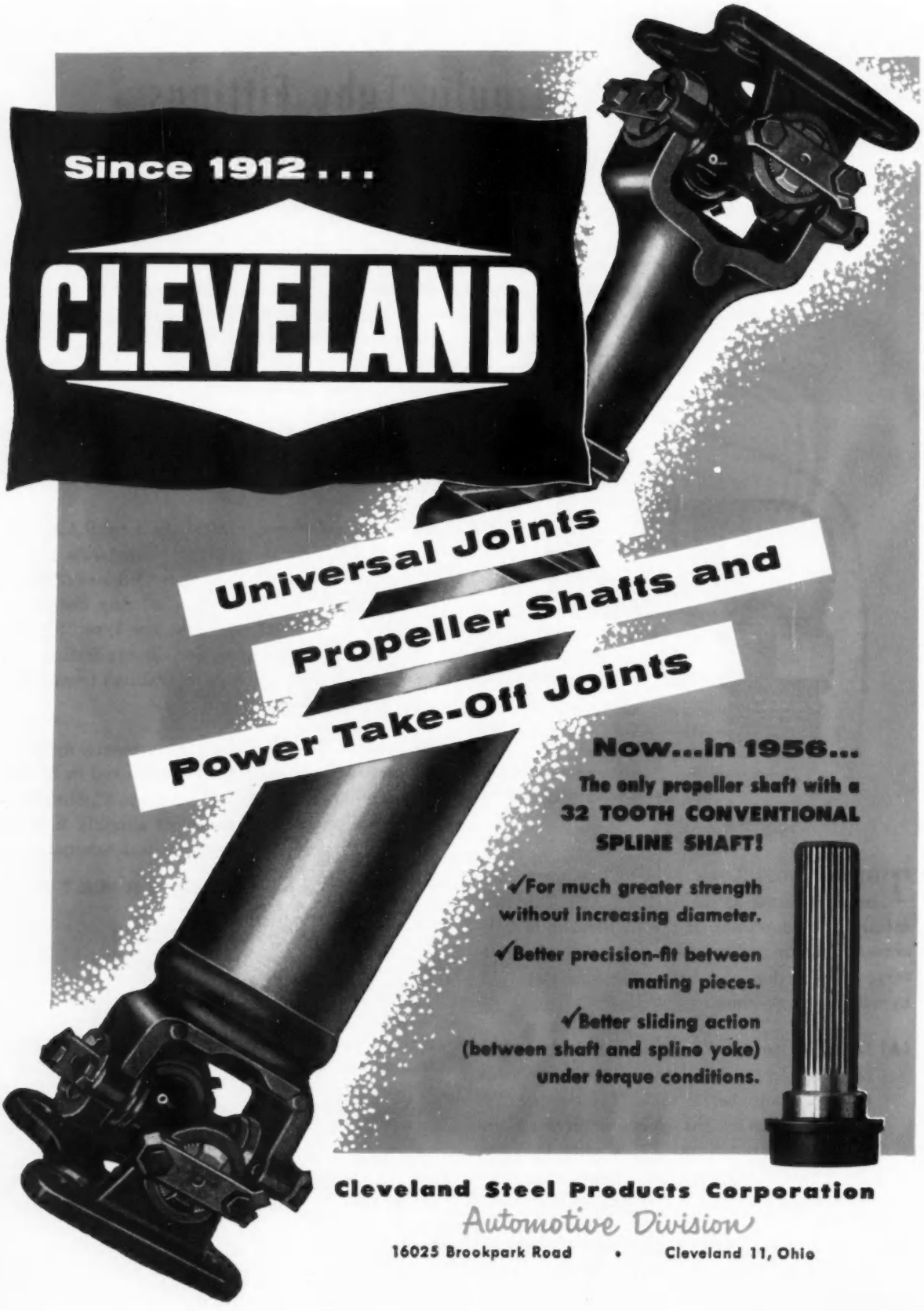
Specifically designed for high-pressure systems, the new Ermeto tube fitting is stocked in 31 different styles and in sizes from ⅛" to 2". Simplicity of design and ease of assembly simplify field replacement, reducing downtime to a minimum.

8000 SERIES ERMETO®



Weatherhead 8000 Series Ermeto flareless tube fittings in steel or stainless steel . . . available in standard styles and sizes for all hydraulic and pneumatic high-pressure applications. Industry's leading high-pressure line connector.

The Weatherhead Company, Dept. AD-10, Fort Wayne Division, 228 West Washington Blvd., Fort Wayne, Indiana. In Canada: The Weatherhead Co., Ltd., St. Thomas, Ontario.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under torque conditions.
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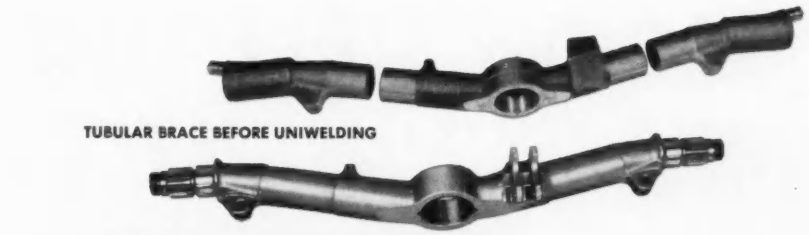
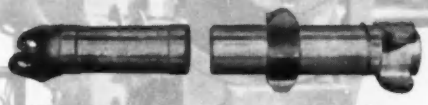


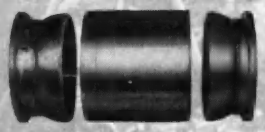
TUBULAR BRACE BEFORE UNIWELDING

TUBULAR BRACE UNIWELDED AND FINISH MACHINED

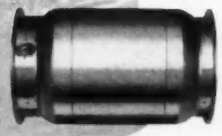


LANDING GEAR CYLINDER BEFORE UNIWELDING

LANDING GEAR CYLINDER UNIWELDED AND FINISH MACHINED



MISSILE TANK COMPONENTS BEFORE UNIWELDING



MISSILE TANK UNIWELDED AND FINISH MACHINED

LANDING GEAR PISTON BEFORE UNIWELDING

LANDING GEAR PISTON UNIWELDED, HARD CHROME PLATED AND FINISH MACHINED

Now... **MENASCO** *can* **UNIWELD** *and* **HARD CHROME PLATE** ***TITANIUM ALLOY*** *components to your specifications*

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Illustrated are typical examples of what MENASCO can do with these two processes to fabricate titanium components for aircraft and missile applications.

Major aircraft manufacturers look to MENASCO for efficient engineering, product development and new fabricating techniques.

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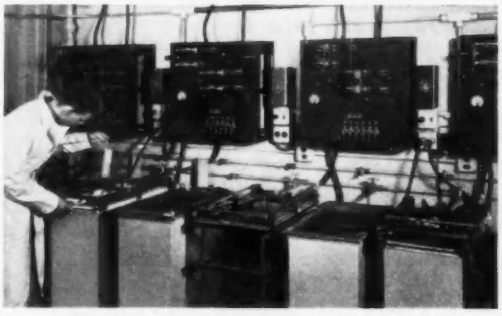

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Century's engineers are the first to accomplish the long dreamed-for wedding of photographic recording and completely automatic dry processing to eliminate the need for costly darkroom facilities and liquid developing, rinsing and fixing.

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NOW investigate CENTURY ELECTROGRAPH—the most modern approach to simplified oscillographic recording — when planning your instrumentation program whether for research, engineering, test, quality control, process control, or any other analog recording requirement.

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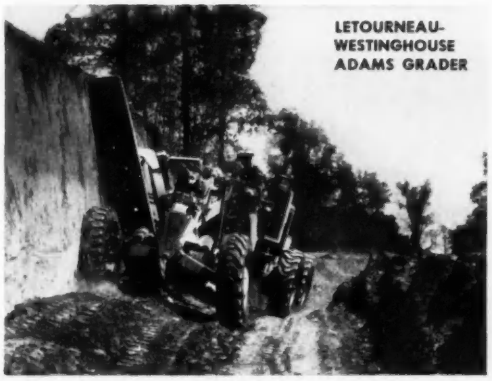
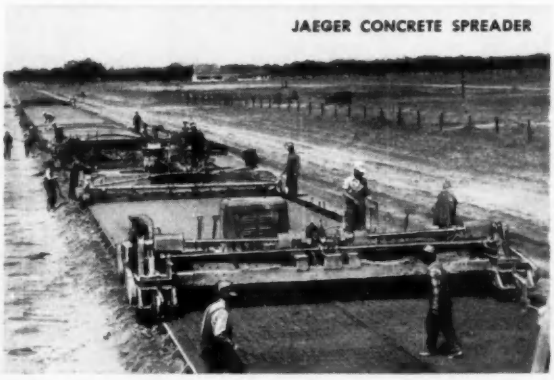


LETOURNEAU-WESTINGHOUSE ADAMS GRADER



JAEGER CONCRETE SPREADER

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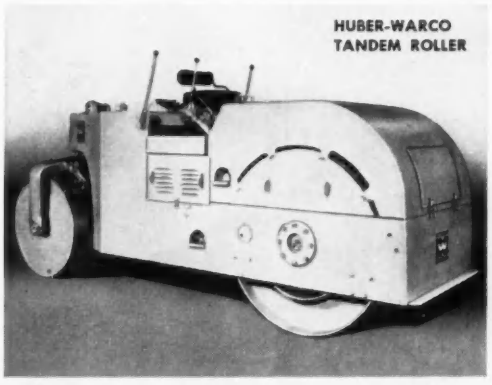

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Supplier-engineering cooperation can often save time when you're designing road building and construction equipment.

At Blood Brothers, a complete staff of engineers is ready to work closely with you. They will gladly assist in selecting standard universal joints and drive lines—or advise on special problems.

As one customer wrote: *"We are seldom able to obtain the prompt and pleasant attention which you have given us in developing these . . . joints".*

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Hardest-working component of the Lockheed F-104 landing gear is its compact liquid spring, engineered and built by Cleveland Pneumatic.

CPT Liquid Springs provide high load absorption within the minimum space available on this razor-wing aircraft. Over 70,000 test cycles proved the reliability of the liquid spring principle.

Whether your aircraft designs permit use of conventional AEROL* shock-absorbing struts or whether razor-thin wings create space problems, CPT will design and build landing gear to handle the job dependably. We've been solving landing-gear problems for over 30 years. Our modern 350,000-square-foot plant is equipped to produce CPT AEROLS or Liquid Springs to fit your production schedule.

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NEW THREAD CUTTING FASTENER

- LOW COST
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Pulls up tight without backup on flat or contoured surfaces

Specially designed to hold die-cast or cold-forged name plates, emblems and trim against sheet metal surfaces, DOT's new T. C. F. cuts clean, deep threads on unthreaded studs, even those that are chrome plated. Immediately available to fit 1/8" and 3/16" studs.

When used with its pre-assembled plastic sealer, the new T. C. F. makes a watertight seal. The sealer *precedes* the fastener onto the stud so that it is not damaged by the thread-cutting process.

Available *in quantity* with or without sealer from Monadnock Mills subsidiary and Carr Fastener Division.

United-Carr's design staff is ready to apply the same engineering creativity that produced the T. C. F. and thousands of other special-purpose fastening devices to the solution of your special fastening problems. Field representatives are located in most principal cities.

T.C.F. for 1/8" stud shown actual size. Also available for 3/16" stud.

T.C.F. for 1/8" stud with plastic sealer.

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THREAD CUTTING FASTENER

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well-developed "muscles" for guided missiles

fuel pumps for special propellants

Special pumps have been developed to handle at either high or low pressure such difficult chemicals as propyl nitrate, nitric acid, ethylene oxide and others still classified; also liquid sodium.

high-speed, high-temperature hydraulic pumps

Newly developed Pesco pumps operate at speeds to 12,000 rpm, temperatures to 400°F. Designed for reliability, extended storage and vital savings in space and weight.

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Miniaturized axial flow blowers with integral motors provide efficient cooling of "hot spots" in electronic equipment under both ground testing and flight conditions.

Now from Pesco come vital components for your missile development program. In working with leading firms holding missile contracts, Pesco has developed the "muscles" to pump propellants and operate controls.

These Pesco products conform to missile criteria: minimum size and weight, instantaneous action after long storage, unfailing dependability despite rigorous operating conditions.

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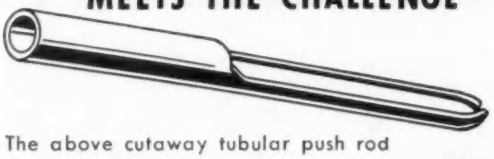
HOW *Fusionweld* MEETS THE CHALLENGE



The above cutaway tubular push rod section with swaged end illustrates one type of push rod design made and fabricated by Avon, then cyanide hardened. It has a low cost factor combined with great strength and toughness, plus essential concentricity.

Special hardened steel inserts (at left) provide other styles of design. These are spot welded in the tube ends, with a maximum runout of .020, to match rigid concentricity tolerances. Illustration at right shows push rod with welded insert subjected to pull-out test of 1500 pounds, which greatly exceeds critical automotive requirements.

Avon's widely accepted Fusionweld Tubular Push Rods have successfully supplanted the heavier, old style solid push rods. Startling economies, plus important improvements in engine performance today place Fusionweld push rods in the forefront of this accepted method of valve accentuation. Fusionweld has today succeeded in creating an enviable reputation for producing top quality, vibration-proof, thin-wall steel tubing. Its exclusive method of hi-cycle resistance welding, coupled with a special process of cold drawing by die sinking now provide a tubing with extreme toughness and hardness to meet the most exacting standards for a fatigue resistant product. Fusionweld's complete homogeneity of grain structure in both wall and weld gives it a new degree of tensile strength and ductility, making it highly resistant to vibration—hence ideal for innumerable automotive applications.

We welcome inquiries on Fusionweld Tubing in random or cut-to-length sizes—or fabricated and formed to your blue print specifications. Sizes 3/16" O.D. to 3/4" O.D. Plain or terne coated. Write for your copy of the Avon Tubing Guide.

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Pioneering in Liquid Propulsion Systems

The Jet Propulsion Laboratory is a stable research and development center located north of Pasadena in the foothills of the San Gabriel mountains. Covering an 80 acre area and employing 1450 people, it is close to attractive residential areas.

The Laboratory is staffed by the California Institute of Technology and develops its many projects in basic research under contract with the U.S. Government.

Opportunities open to qualified engineers. Inquiries now invited.

Development work in liquid propulsion systems began at the Jet Propulsion Laboratory in 1943. This led to the first practical rocket powerplant in the United States in which spontaneous ignition took place upon mixing of the oxidizer and fuel.

This pioneering achievement in the liquid propellant systems opened the way for a vast number of engineering developments in the rocket motor field and in complete missile systems. One of the first applications was to develop motors to assist take-off of aircraft. The next application of the acid-aniline propellant system was to propel the WAC Corporal sounding rocket. This was the first American liquid propellant missile.

The propulsion system used in the Corporal, a mobile surface-to-surface missile system, is of the same basic design. Other successful missiles using the same principle have recently been developed.

Research continues at the Laboratory in the field of chemistry for propellants that will power the missiles of the future. Other activities such as chemical investigations, research and development in the motors, airframes, structures, guidance and all other parts of the missile system are continuously in progress. Stimulating opportunities for individuals desiring a career in the areas of basic and applied research and actual development engineering are now available.

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A DIVISION OF CALIFORNIA INSTITUTE OF TECHNOLOGY
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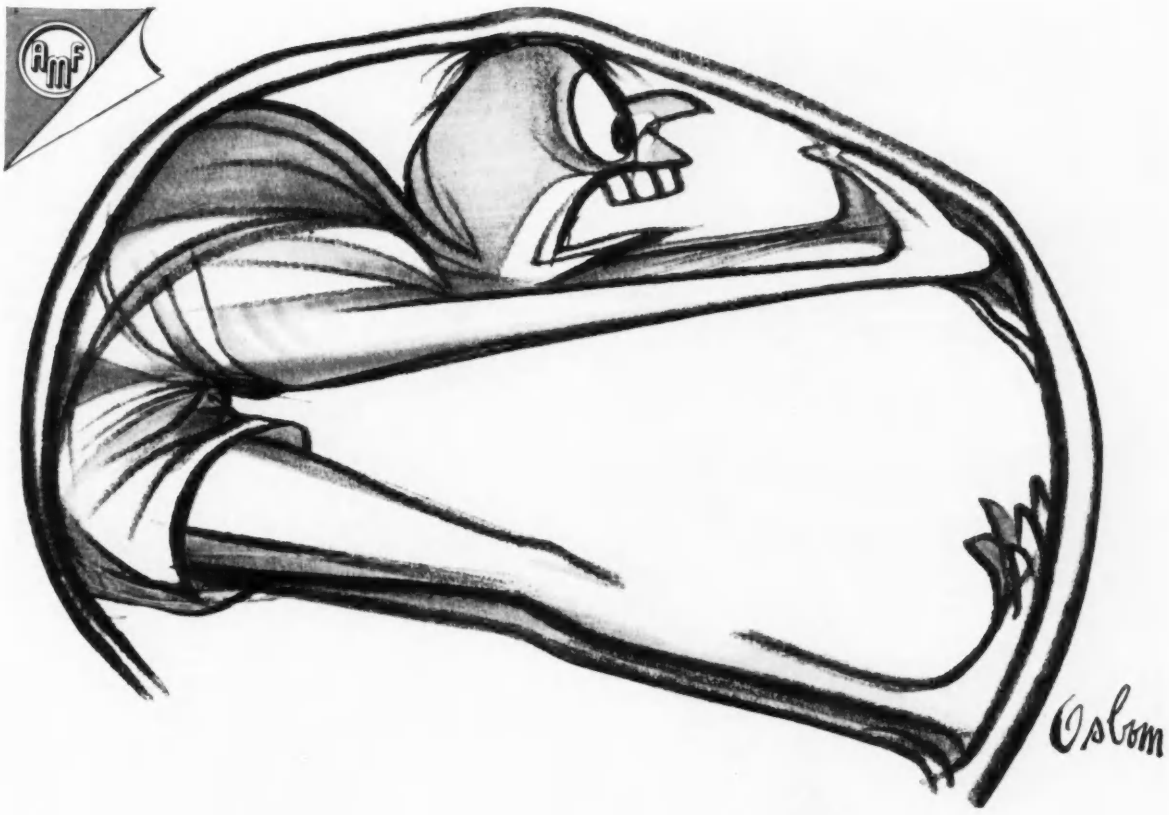

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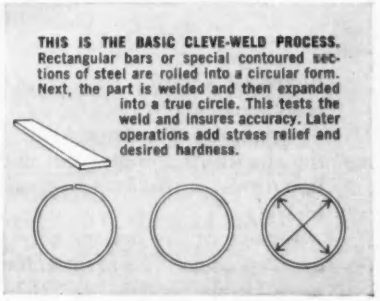
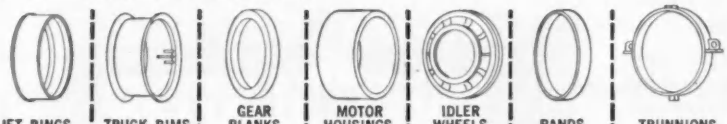
Top Jet-Engine makers specify Cleve-Weld rings

The *design, metallurgy* and *production* of welded circular parts have been Cleve-Weld specialties for 45 years. We've worked with materials from carbon to stainless and the latest aircraft alloy steels. Cleve-Weld has the specialized equipment and experience to do exacting jobs. These are the reasons why America's jet-engine makers procure Cleve-Weld rings. Pratt & Whitney J-57, Wright Aeronautical J-65, General Electric J-47 and other great jet engines testify to our ring accuracy.

Cleve-Weld is also a prime supplier of truck and tractor rims, rings, bands and gear blanks. *Make Cleve-Weld your primary source for all rolled and welded circular parts, too.* We'll show you why in dollars and cents. Write Circular Welded Products Sales Department below.


THIS IS THE BASIC CLEVE-WELD PROCESS.
Rectangular bars or special contoured sections of steel are rolled into a circular form. Next, the part is welded and then expanded into a true circle. This tests the weld and insures accuracy. Later operations add stress relief and desired hardness.

EXAMPLES OF CLEVE-WELD PROCESS PRODUCTS



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RIMS · RINGS · WELDMENTS

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Purolator's "SELECTIVE" FILTRATION leaves additives in

Beneficial additives stay in as HD and heat-resistant lube oils pass through the Micronic® element of a Purolator filter . . . even though the element is straining out sludge, water and impurities as small as one micron (.000039-inch).

It's one of the reasons why original equipment manufacturers in the automotive field use more Purolators than any other make of filter. Besides this "selective" filtration, the accordion-pleated Micronic element provides ten times the area of older types, making possible:

- ***High flow rates with minimum pressure drop.*** **Purolators themselves can be small . . . yet operate with pumps of standard size.**
- ***Maximum dirt storage capacity . . .*** **for long, efficient service life before replacement.**

Micronic elements do not channel. They are waterproof and warp-proof and remain unaffected by engine temperatures. There's a Purolator to fit every vehicle, tractor and other gasoline- or diesel-engine-powered unit in service today. Write for our automotive catalog, No. 2054, to Purolator Products, Inc., Rahway, N. J., Dept. A5-1017.

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QUALITY HOT PARTS FOR MORE U. S. JETS

Two-thirds of America's newest, fastest models of Air Force and Navy combat aircraft depend upon Ryan jet engine components. From its modern 43-acre plant Ryan delivers these precision-built, high-temperature assemblies to the major jet engine manufacturers, who produce the power plants for America's defense armada.

Jet engine builders look to Ryan's Metal Products Division for "hot parts" because it has specialized for 20 years in designing and producing these complex high-temperature structures. Ryan is uniquely skilled and equipped to build the first experimental units of difficult designs and then streamline these prototype designs for efficient low-cost, volume production of the final models.

In addition to "hot parts" for turbojets and afterburners, this major division of Ryan also produces powerful rocket motors and a wide range of components for ramjets, turbo-compound and piston engines.

For 33 years, Ryan has excelled in designing and producing high quality aircraft, power plants and avionics—built at low cost, delivered on time.

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Now...moisture-free air for air brake systems

New Wagner moisture ejection valve keeps reservoirs clean and dry—*automatically!*

Since moisture accumulation in the brake system can be a problem, you'll be interested in this fully automatic moisture ejection valve.

Operating at 15 to 20 p.s.i. pressure, it ejects moisture with each average brake application.

It mounts in any convenient location . . . no heating element is necessary as the valve cannot freeze in open (exhaust) position. It connects to the air system by two air lines—one leading from the bottom of the air reservoir and the other from a brake application line.

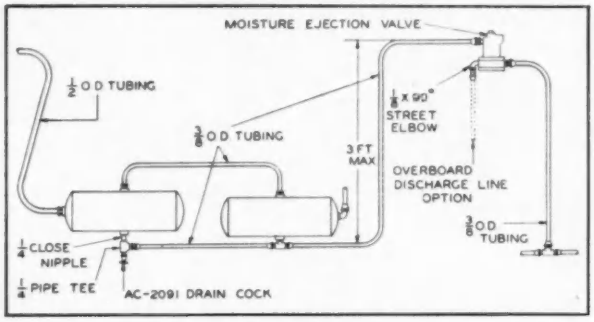
Expulsions occur without a noticeable drop in tank gauge pressure.

HIGH CAPACITY—valve can eject up to 4 fluid ounces at a time . . . even expels foreign particles which may have settled to the bottom of the tank.

CORROSION RESISTANT metal parts. Diaphragms are a combination of neoprene and nylon cord for long life and high resistance to oil.

OPEN TO ATMOSPHERE—valve fluid cavities are open to atmosphere . . . it is impossible to trap moisture within the unit. *Cannot balance in open position* . . . and "dump" reservoir pressure.

TYPICAL PIPING DIAGRAM



Wagner Air Brake Application Valves for Straight Air Systems

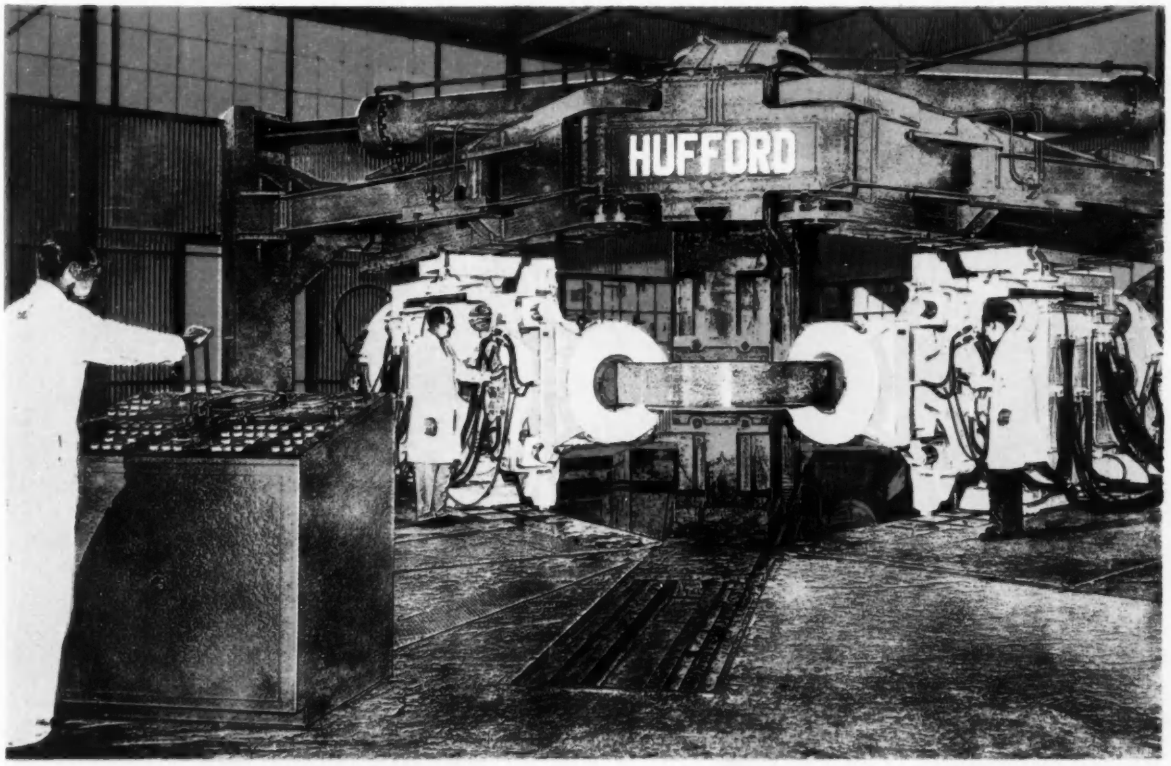
These valves provide complete braking control for safe, sure stops. Each valve is completely interchangeable with other makes of valves. The basic valve can be installed by simply transferring the actuating mechanism to the Wagner valve. The treadle valve can be adjusted to angle properly with the contour of the floor board and also offers external adjustment of exhaust valve clearance.

For complete information on Wagner Air Brake Systems, write today for Catalog KU-201A.

K5a-3R

WAGNER ELECTRIC CORPORATION, 6378 PLYMOUTH AVE., ST. LOUIS 14, MO.

LOCKHEED HYDRAULIC BRAKE PARTS and FLUID • NoRoL • CoMaX BRAKE LINING • AIR BRAKES • AIR HORNS • TACHOGRAPHS • ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES



350-TON HUFFORD STRETCH FORMER — PART OF ROHR'S MULTI-MILLION DOLLAR TOOL KIT

This giant Rohr machine is one of the two largest of its kind in the world. It permits the forming of an increasing variety of large size stringers, stiffeners, skins and fillet fairings . . . it makes possible the forming of deep outsized contoured parts considerably beyond the capacity of standard stretch machines and conventional presses.

Today, with this and hundreds of other heavy manufacturing machines, Rohr produces over 30,000 different parts for aircraft of all types. This is, of course, in addition to Rohr's being recognized as the world's largest producer of ready-to-install power packages for airplanes.

For design and engineering know-how, for full production facilities look to Rohr to build more into the aircraft parts you need.

In addition to the Boeing KC-135 shown here, Rohr builds power packages for many other leading commercial and military planes which have made Rohr famous as the

WORLD'S LARGEST PRODUCER OF READY-TO-INSTALL POW-R-PAX FOR AIRPLANES

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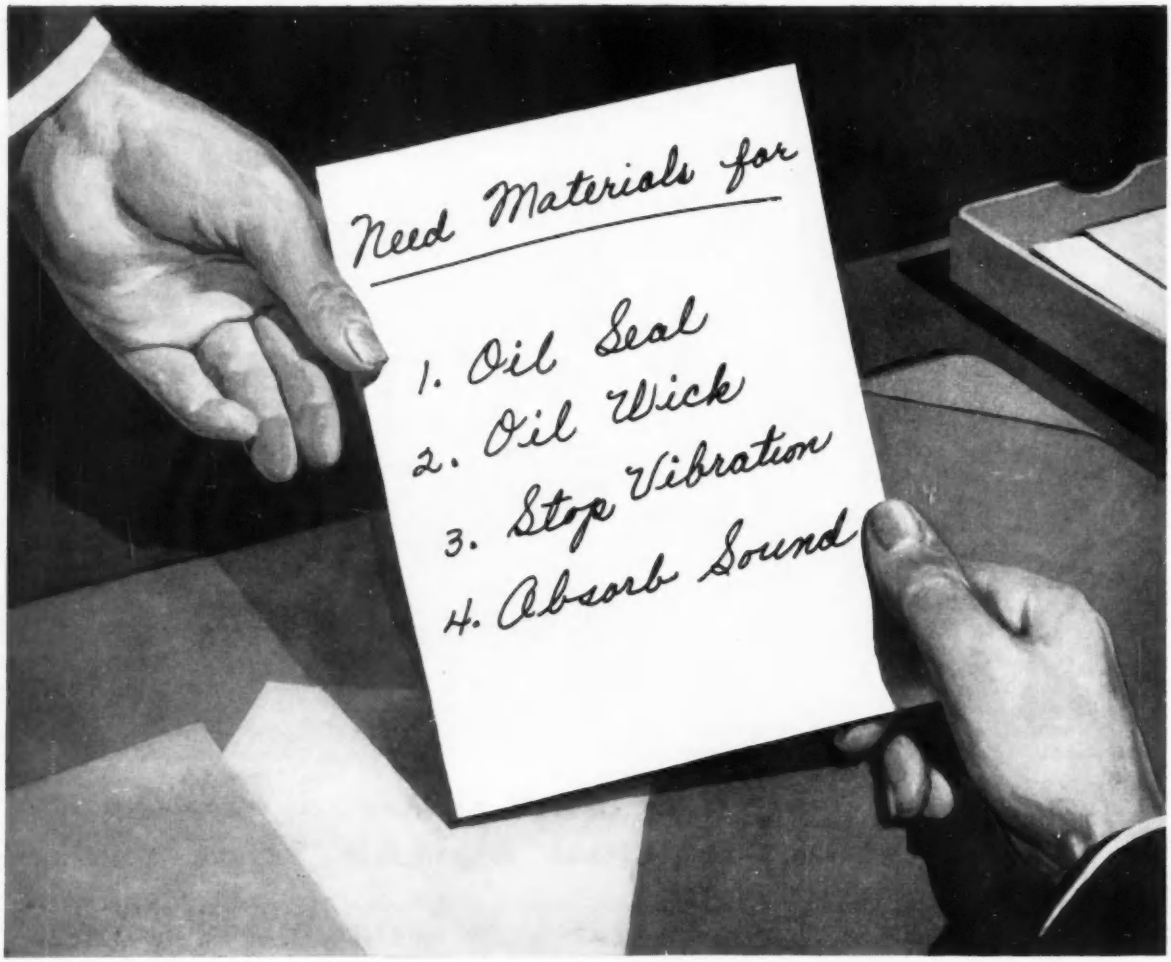
Excellent career openings now for engineers and skilled technicians

Plants in Chula Vista and Riverside, California; Winder, Georgia — soon to be in Auburn, Washington



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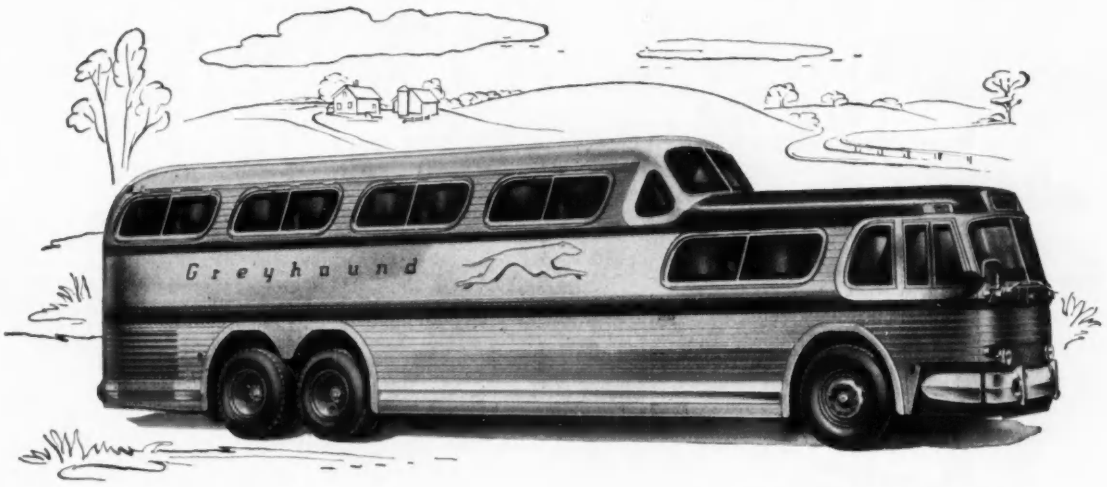

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Performance of Vickers Hydraulic Power Steering on 700 Greyhound Highway Traveler Coaches brought about its use on the first 500 Greyhound Scenicruisers. Experience with these Ultra-Modern Coaches induced Greyhound to order 500 more . . . making 1,000 Scenicruisers with Vickers Hydraulic Power Steering.

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Vickers Hydraulic Power Steering is easily applicable to new and existing vehicle designs . . . usually with very minor alteration. Get additional information by asking for Bulletin M-5106.

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There is more to the superiority of the forged crankshaft than just strength.

No other method of fabrication can compare with the forging process for dependability. The uniformity and predictability of physical properties with minimum variance from piece to piece or from one location to another in the same piece is assured to the greatest degree by modern forging practice.

Top automotive engineers agree that the use of a forged crankshaft permits the design of a more compact engine which is a decided advantage when thinking in terms of limited space available and overall engine weight reduction.

As compression ratios increase and engine outputs go up the risk factor must be reduced. Again, the uniformity of quality in the backbone of the engine, the crankshaft, is most essential and made possible only by a forging.

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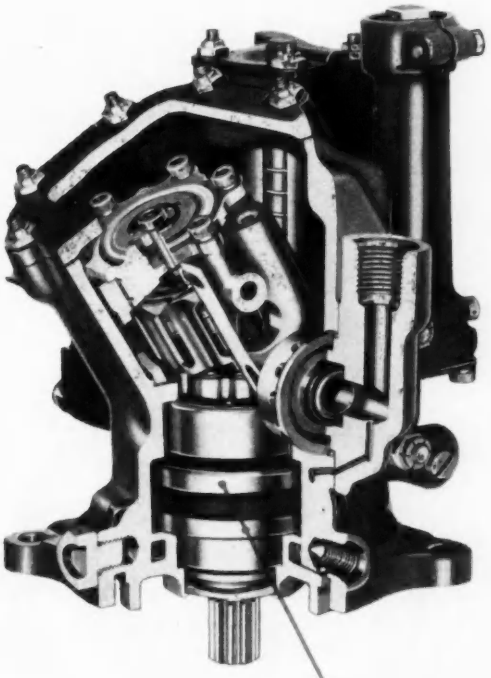
ONE AETNA BEARING DOES A FORMER TWO BEARING JOB



RESULT:

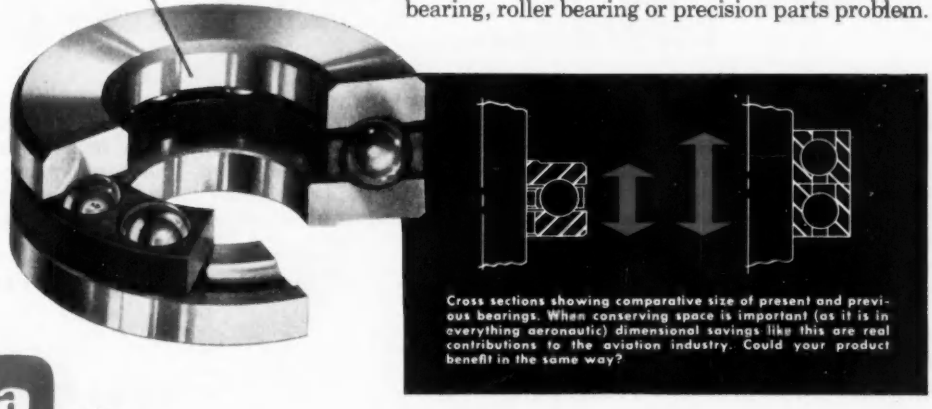
A LIGHTER, SMALLER PUMP WITH FEWER PARTS PLUS IMPROVED PERFORMANCE AND RELIABILITY

This recently improved variable displacement piston type pump packs more power in less space than any other pump made—has, in fact, notably higher efficiency with a third less of the weight and size of its previous design.

To achieve this significant miniaturization job the pump makers turned to Aetna for assistance in "shrinking" the all-important anti-friction bearing units. You see the result here: one special, space-conserving Aetna thrust bearing tailored to do the job that formerly required two conventional-size angular contact bearings.

This example of how Aetna is helping industry compress its products into smaller, cost-cutting dimensions is not at all exceptional. For 40 years solving difficult friction problems to help make good products better has been one of Aetna's most intensified engineering activities.

We invite you to use that wealth of specialized engineering knowledge whenever you have a ball bearing, roller bearing or precision parts problem.



Cross sections showing comparative size of present and previous bearings. When conserving space is important (as it is in everything aeronautic) dimensional savings like this are real contributions to the aviation industry. Could your product benefit in the same way?

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advanced design in turbochargers means... air-cooling!

AiResearch turbochargers possess this all-important characteristic

There's little quarrel in the diesel industry about the air-cooling principle being highly-desirable in a turbocharger. It eliminates the need for extra plumbing on installation, puts no additional burden on an engine's cooling system and makes for a lighter, smaller unit in relation to output.

AiResearch turbochargers now available have been designed on this principle — which promises to be universal in the future. In addition, our units increase power up to 100% depending on design and application of your engine, cut fuel costs, reduce noise and decrease or eliminate smoking. The removable rotating assembly makes them easier to maintain than other turbochargers.

We invite your inquiry on how you can improve the performance of your diesels by the application of our turbochargers.

BASIC SPECIFICATIONS FOR AIRESEARCH TURBOCHARGERS

MODEL	T-10	T-14	T-15	T-30-2	T-30-6
Diameter — in. nom.	9	11.5	15.25	15.25	16
Length — in.	9	14.12	16.75	17.25	21.75
Weight — lb.	40	95	125	135	195
Output — lb/min. (Standard Conditions)	25-40	35-65	35-65	70-95	115-175

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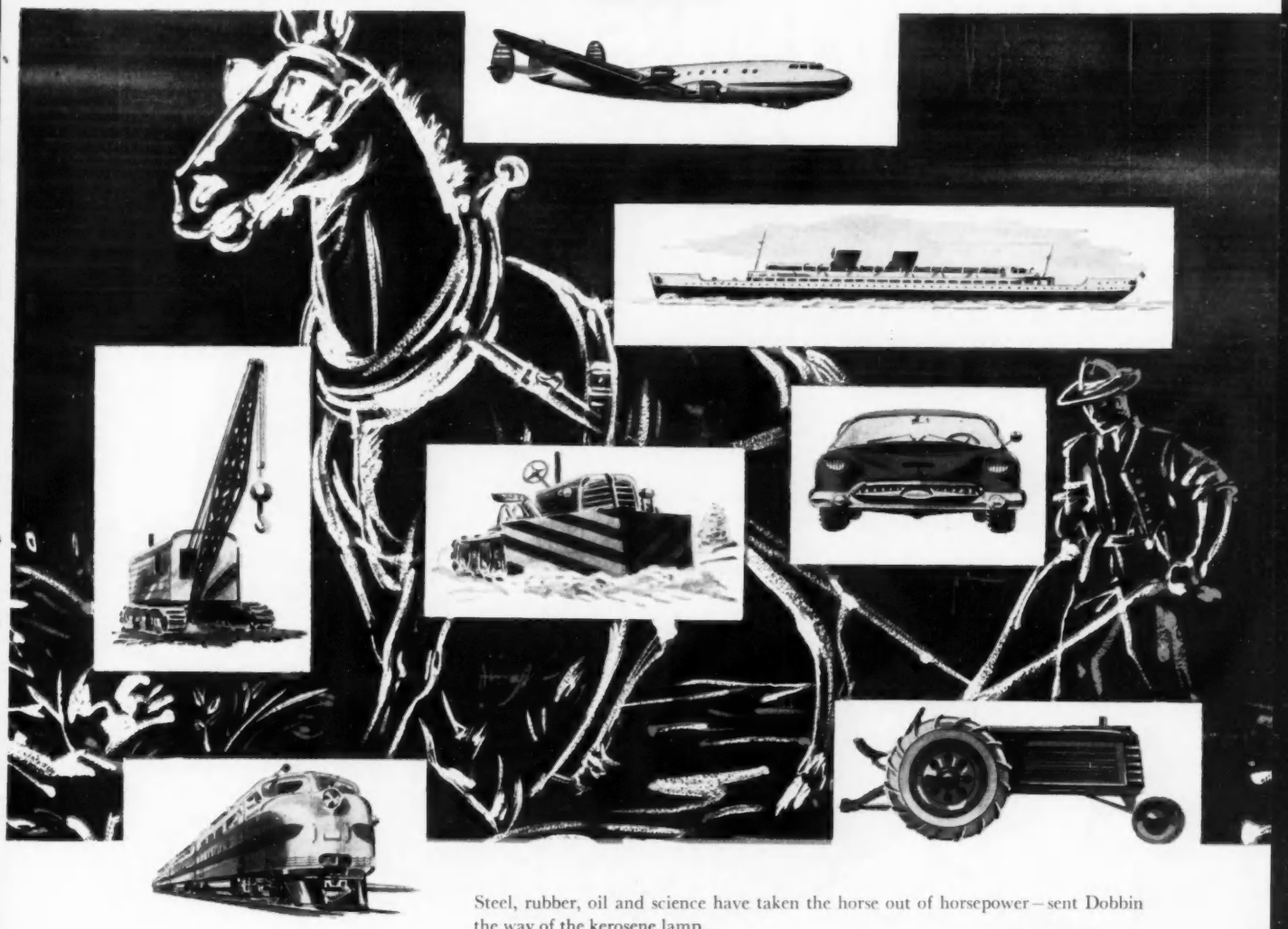
AiResearch Industrial Division

9225 South Aviation Blvd., Los Angeles 45, California

DESIGNERS AND MANUFACTURERS OF TURBOCHARGERS AND SPECIALIZED INDUSTRIAL PRODUCTS

Naugatuck Paracril



the new horsepower needs oil-resistant Paracril!

Steel, rubber, oil and science have taken the horse out of horsepower—sent Dobbin the way of the kerosene lamp.

The *new* power is OIL—oil that burns—oil that transmits silent fluid power in hydraulic systems—oil that lubricates moving parts.

And PARACRIL* is the modern oil-resistant chemical rubber that's outstanding for its ability to control the power of oil—in gaskets, seals, hydraulic hose and similar applications.

Highly resistant to animal, vegetable and mineral oils, fats and greases, PARACRIL also provides excellent *abrasion resistance*, good *flexibility* over a wide temperature range, great *dimensional stability* and lasting *resilience*. That's why this Buna-N (nitrile-type) rubber made by Naugatuck Chemical is more and more in demand by manufacturers of rubber products that operate in contact with oil.

Remember the name PARACRIL whenever you think of maximum oil-resistance in rubber. It's your best assurance of long, trouble-free performance in pressure seals, hydraulic hose and accumulator bladders.

***PARACRIL is Naugatuck Chemical's registered trademark for its Buna-N (nitrile-type) synthetic rubber.**

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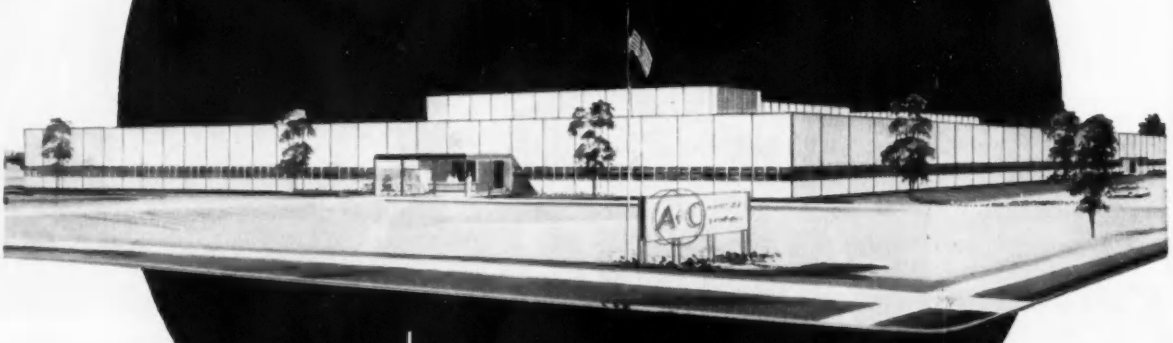

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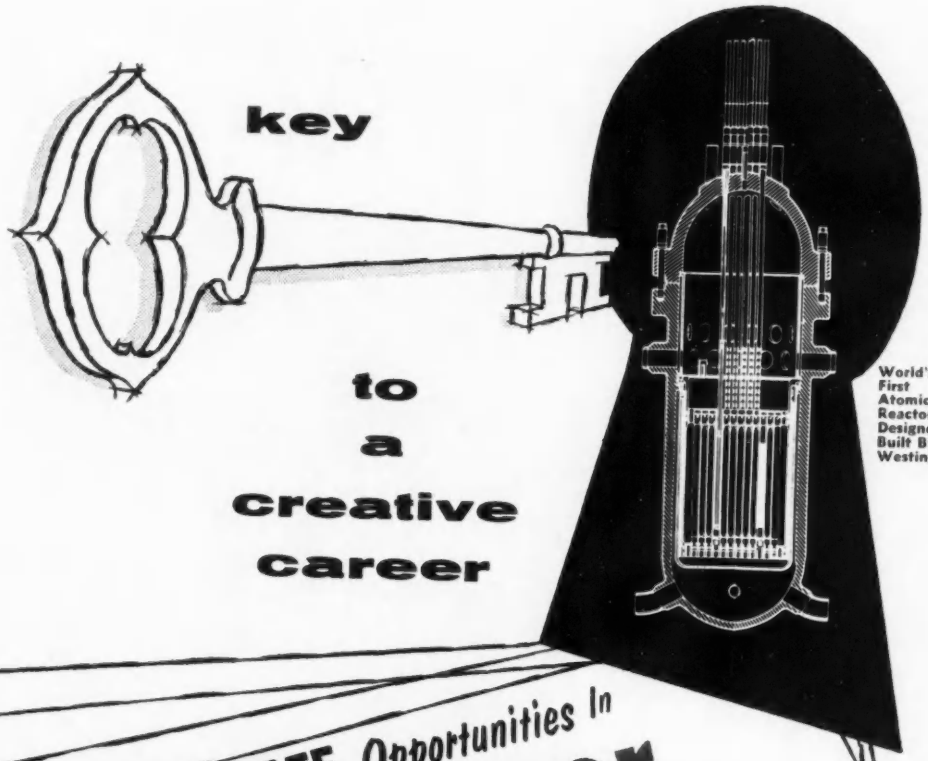

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Take this unique opportunity to become associated with an exciting new organization. Your career begins immediately. Participate in provocative assignments that go far beyond simply whetting your creative appetite . . . assignments that hold the promise of limitless professional growth.

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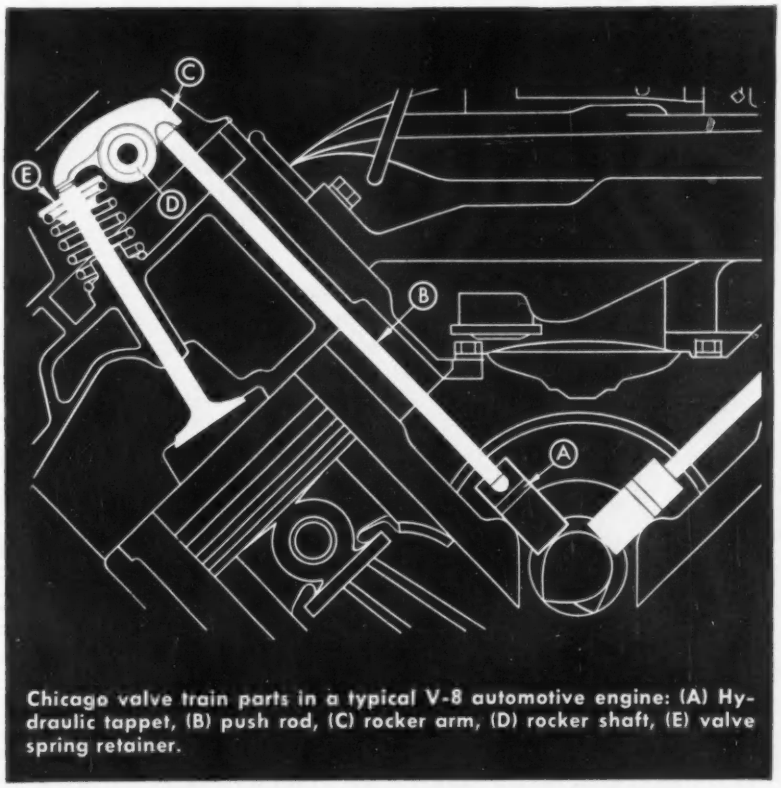


Chicago valve train parts in a typical V-8 automotive engine: (A) Hydraulic tappet, (B) push rod, (C) rocker arm, (D) rocker shaft, (E) valve spring retainer.

When it comes to valve gear, leading engine makers come to

CHICAGO

Here at Chicago you'll find a single source for everything you need in valve gear. These specialized facilities are solving problems and saving money for leading engine manufacturers . . . and can do the same for you.

Design and Engineering—at Chicago you'll find valve gear engineering experience in depth . . . men who understand your problems and will work with your engineering staff in designing cam shafts and complete valve gear assemblies for any type of engine.

Manufacturing—Chicago is a leading manufacturer of valve train parts. Our complete line includes precision-made hydraulic and mechanical tappets; push rods in both lightweight tubular and solid styles; valve adjusting screws including new self-locking screws that cut assembly costs; valve spring retainers; rocker arms and rocker shafts.

Testing—we have complete laboratory and engine testing facilities.

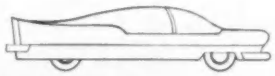
For the full story of how we can serve you, write our Tappet Division.

THE CHICAGO SCREW COMPANY

DIVISION OF STANDARD SCREW COMPANY • ESTABLISHED 1872

2521 WASHINGTON BOULEVARD, BELLWOOD, ILLINOIS

Imagineering the 195X models . . . in Alcoa Aluminum



Engineers play Sherlock Holmes to measure piston temperatures

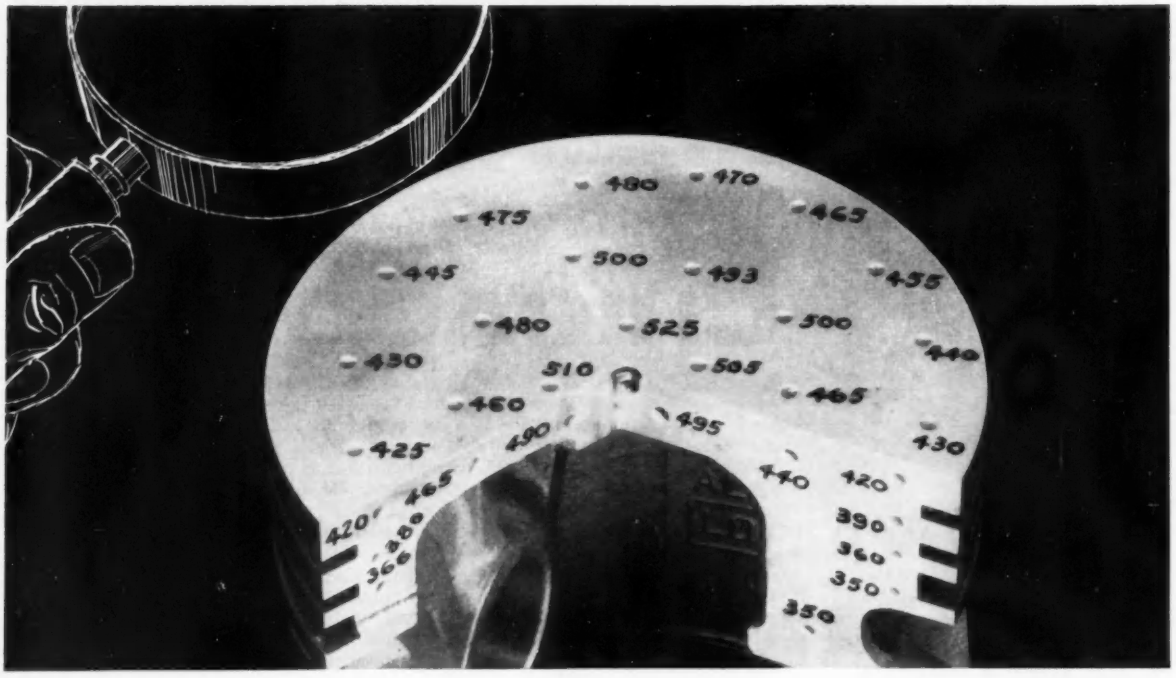
Everyone knows there's a raging inferno inside the cylinders of an internal combustion engine but specific temperatures are hard to determine. Engineers could only guess the answer to the question: "How hot do pistons get?"

Instrumentation for temperature determination in a piston traveling up and down hundreds of times per minute is difficult and short lived. This was the problem faced by the engineers at Alcoa's Cleveland Development Laboratories. Yet the mystery was solved in a manner that would do credit to the famous Sherlock Holmes. The "clue" that broke the case was the fact that aluminum of a special alloy and temper loses hardness due to accelerated aging when exposed to high temperatures. The drop in hardness is very closely related to the temperature and the exposure time.

Pistons cast from this special aluminum alloy were run in an engine at specified test conditions for a recorded number of hours. Then they were removed and shipped to the Alcoa Development Laboratory in Cleveland for Brinell hardness tests.

Actual hardness was compared with the known curves to determine accurately the operating temperature of critical locations in the piston. Variations from cylinder to cylinder in cooling characteristics and inlet manifold distribution become evident from a complete piston temperature survey.

In this case, the superb facilities and imaginative people of Alcoa's Development Division produced data which result in still better aluminum pistons. We would like to use these facilities and these people to help you imagineer better parts for *your* 195X (or 6X) models . . . from Alcoa® Aluminum.



Problem: Determine piston operating temperatures. Method: Alcoa engineers measured the "drop in hardness" which was then correlated with operating temperatures. Result: Better pistons. Suggestion: Let our superbly equipped Development Division help *you* imagineer your new aluminum parts. Aluminum Company of America, 1844-K Alcoa Building, Pittsburgh 19, Pa.

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TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

Always Fasten Aluminum With Alcoa Aluminum Fasteners

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Your Guide to the Best in Aluminum Value

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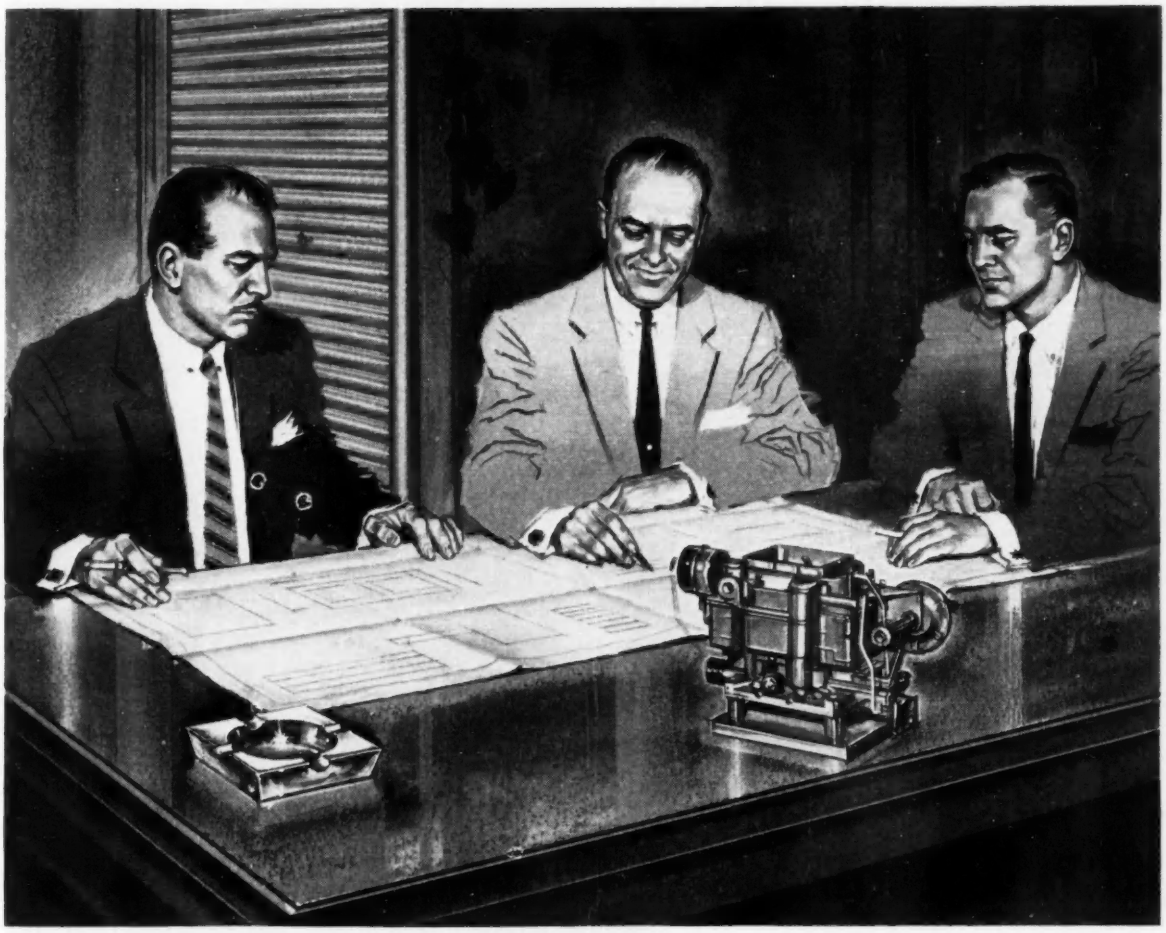

Some People are Never Satisfied

Hardly is a new model carbureter or fuel pump in production, but Carter's development engineers are figuring out ways to improve it. Good engineers are like that... and we are glad of it. From the never-satisfied minds and restless imaginations of Carter engineers have come many important fuel system developments. *Among the most recent and notable was the successful four-barrel carbureter design.*

When new products are developed you may be sure that they will be backed by the same engineering skill that makes today's Carter fuel system products so successful.

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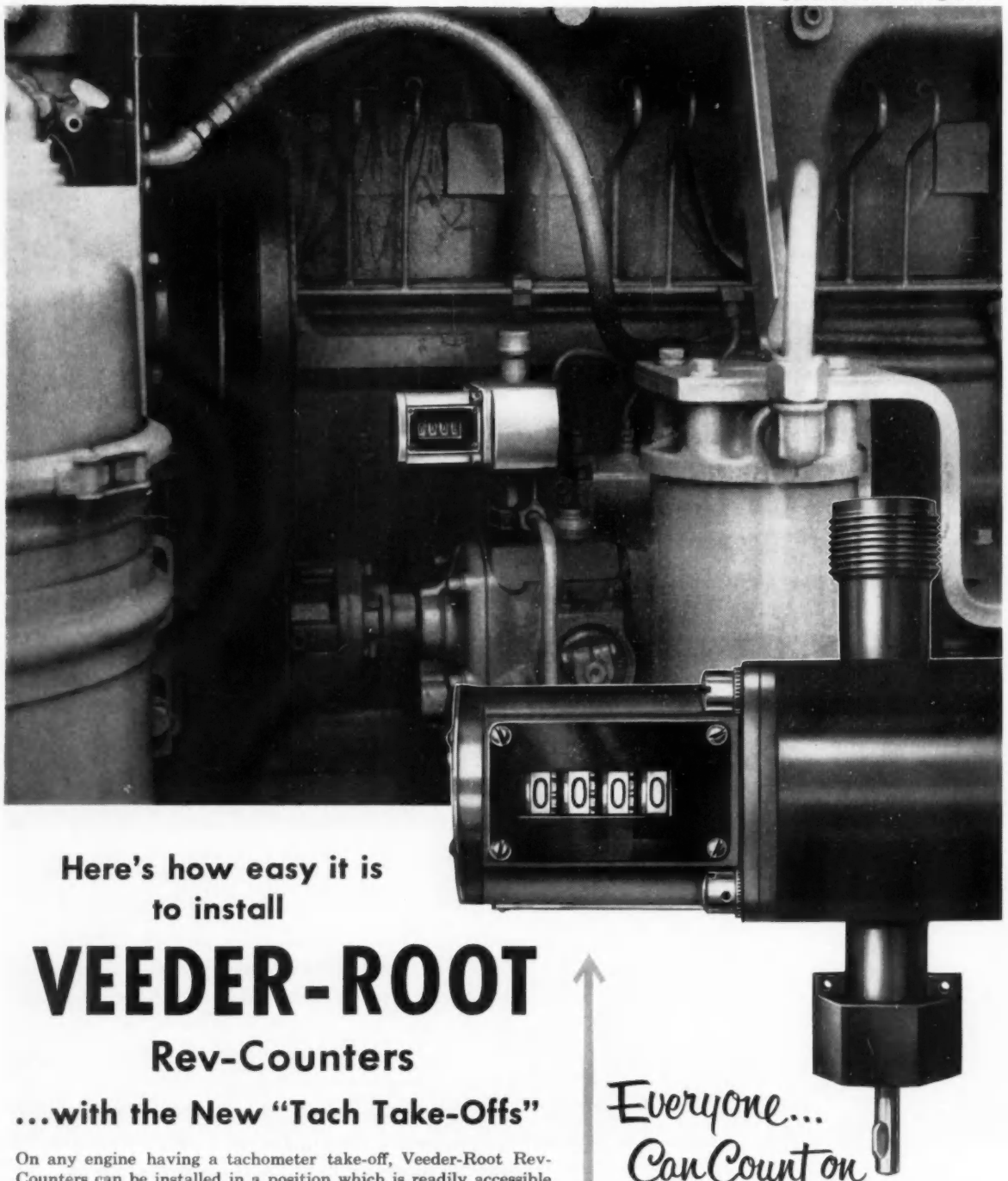

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VEEDER-ROOT

Rev-Counters

...with the New "Tach Take-Offs"

On any engine having a tachometer take-off, Veeder-Root Rev-Counters can be installed in a position which is readily accessible for easy reading . . . so the man who reads the counter doesn't get all messed up or get a crick in his neck.

In fact, with these new attachments, Veeder-Root Rev-Counters make it easy for anyone to see how your equipment is living up to its guarantee . . . when routine maintenance is coming due . . . and to get other valuable facts-in-figures.

You can count on Veeder-Root to help you engineer these adaptable counters not only into engines, but into generators, compressors, heaters, and other equipment. And you will find . . . as other manufacturers of power-units have found . . . that when you build in Veeder-Root Counters, *you build up sales.*

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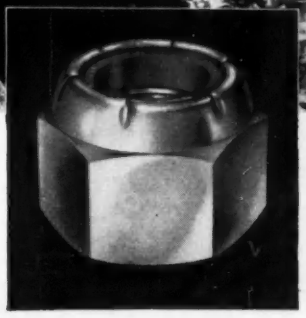
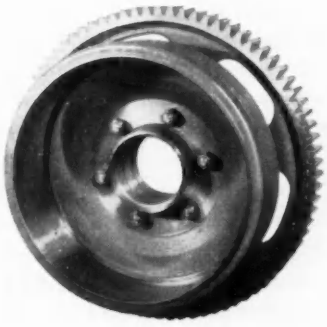


On Link-Belt's new one yard shovel...

ELASTIC STOP® nuts remain tight under terrific shock loads



Elastic Stop nuts secure clutch drums to gears.

The engineering concept behind Link-Belt's new LS-98 Shovel-Crane provides a highly portable machine with big shovel characteristics plus stepped-up work cycles that produce substantial increases in capacity. To do this, the shovel-crane had to be built to stand up under heavy vibration and extreme shock loads. That's why Elastic Stop nuts were chosen for the critical fastening jobs throughout (i.e., hook rollers to brackets, clutch drums to gears, counterweight to upper frame, drum laggings to brake drums, engine mountings, side housing to revolving frame, etc.).

The locking principle of Elastic Stop nuts has been tested and proved by over 25 years of actual field service on equipment like this in every conceivable product of industry from locomotives to roller skates. What's special about this nut? For one thing, you can "stop" it at any position on the threaded length of the bolt . . . or wrench it tight against the work. No matter where you leave it on the bolt, it will remain tight in that exact position, even though you subject it to heavy vibration and shock loads. Reusable many times.

Elastic Stop nuts are available from a watchmaker's 0-80 all the way to 4"—in stainless steel, brass, aluminum and other alloys. Protect *your* product with "fastener insurance." We'll supply free test samples.

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Elastic Stop Nut Corporation of America
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Please send me the following free fastener information:

☐ ELASTIC STOP nut bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

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TRUCKING . . . Vital Transportation Link

Transmission Repairs only .0003c (3/10 mill) per mile at SUPER SERVICE

after an average of 210,176 miles on each of 172 Fuller Transmissions

"With the Fuller ROADRANGERS in our fleet, we've hit an all-time low in transmission repair costs," says Ray Carter, Director of Engineering for Super Service Motor Freight Co., Nashville, Tennessee.

Super Service recently completed a careful check of maintenance records for 172 White tractors equipped with Fuller 10-speed Semi-Automatic ROADRANGER Transmissions. With an average of 210,176 miles per tractor, company records showed a remarkable average repair cost of *only .0003c (3/10 of a mill) per mile for each* ROADRANGER *Transmission!*

About two years ago, Super Service standardized its entire over-the-road fleet on White tractors equipped with ROADRANGER Transmissions and Cummins diesel engines. From that time on, old performance records began to fall.

Operating from the South to the East . . . with terminals from Nashville to New York . . . the ROADRANGER equipped tractors pull square nose, 35-foot aluminum trailers that average 52,500 lbs. gross tare weight. The tractors now cut a full hour off the old 10-hour trip time on the Nashville-East run . . . taking rugged Tennessee hills at 35 miles an hour when 15 was considered a good speed with the old equipment.

Super Service cuts running time and maintenance to a minimum by running its rigs straight through from Nashville to New York. Drivers are changed twice . . . but there's no need to warm up a cold engine at each stage of the relay.

For your fleet, get the facts on ROADRANGERS from your truck manufacturer or truck dealer now.

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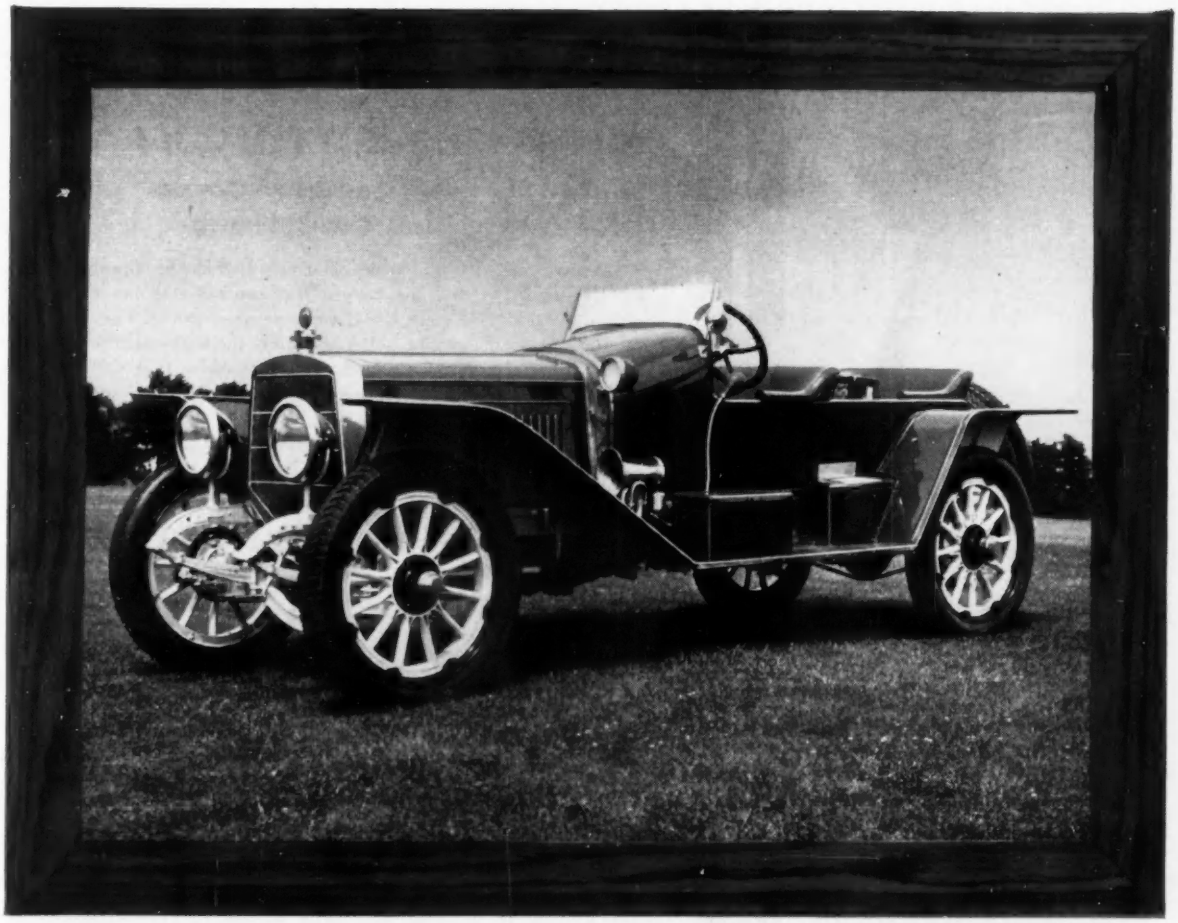

Send for free print—1913 Lozier. This print, from collection of P. S. DeBeaumont, not for commercial use.

"Legitimately high-priced," the 1913 Lozier cost over $5000. It featured a modified toy tonneau body, a T-head six-cylinder engine with 51 h.p. and a top speed of 81 m.p.h. Ignition was dual battery and magneto. From 1907 to 1911, the Lozier maintained an enviable racing record. This is one of a series of antique automobile prints appearing in Morse advertisements. Write for your free copy, suitable for framing, to: Morse Chain Company, Ithaca, N.Y.

Over 75,000,000 Morse Timing Chains insure long service life of cars, trucks, and buses

On nineteen of the twenty-two current makes of cars, *Morse Timing Chain Drives* are specified as original equipment. Over the years, the auto industry has used more than 75,000,000 of these durable Morse Chains. Precision-built Morse Drives give car, bus, and truck owners long service life—plus freedom from maintenance worries.

If you have problems involving timing chain in design, development or application, check first with Morse. We have expert engineering service available to help you solve them quickly, profitably.

For further information, call, wire, or write: MORSE CHAIN COMPANY, ITHACA, NEW YORK.

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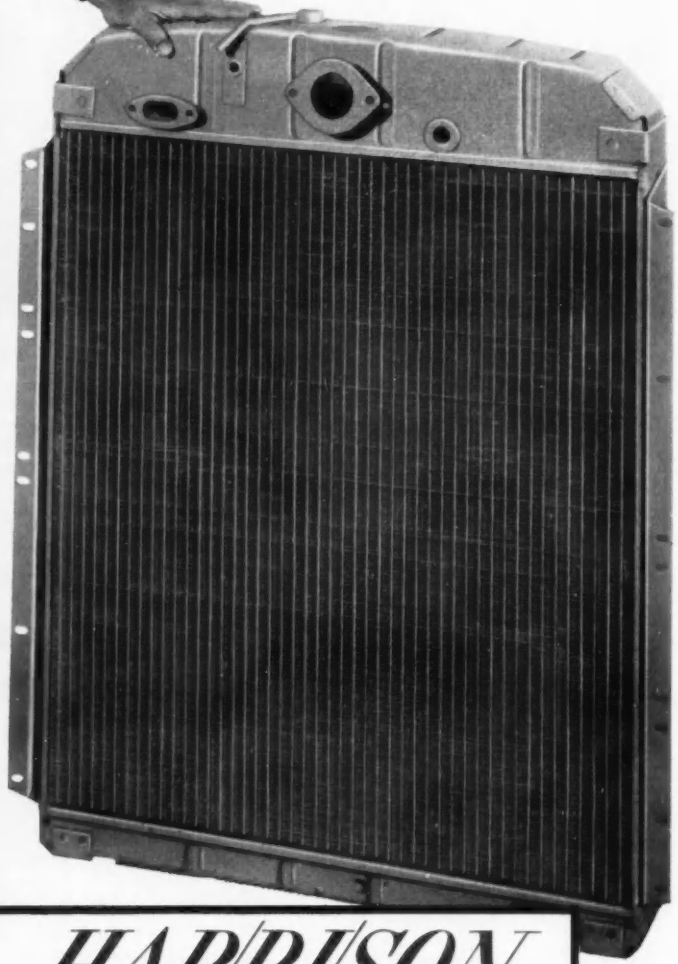
KING-SIZE COOLER for a KING-SIZE TRUCK!

Giant Harrison Radiator Cools Diesel-Powered GMC Truck

When the going's hot and heavy, Harrison cuts the heat problem down to size! There's a big, rugged Harrison radiator out in front of every one of these giant GMC diesel-powered trucks. For Harrison packs the cooling power to handle the heat over the longest hauls with the heaviest payloads. It's no wonder that GMC specifies Harrison heavy-duty, high-capacity cooling equipment. They know they can depend on Harrison . . . with over 46 years' experience in the design, research and manufacture of automotive heat controls. If you have a cooling problem, look to Harrison for the answer.

Watch "WIDE, WIDE WORLD"
Sundays on NBC-TV



TEMPERATURES MADE TO ORDER

GM GENERAL MOTORS

HARRISON

RADIATOR DIVISION, GENERAL MOTORS CORP., LOCKPORT, N.Y.

MAKE IT WEIGH LESS

N·A·X

HIGH-TENSILE STEEL

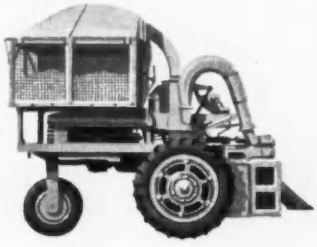
MAKE IT LAST LONGER

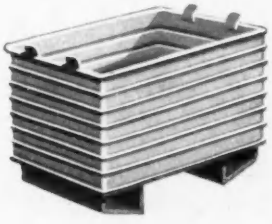
You can design light weight, longer life, and economy into your products by including N-A-X HIGH-TENSILE in your plans.

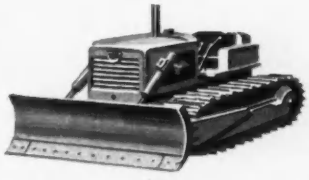
- It is 50% stronger than mild steel.
- It is considerably more resistant to corrosion.
- It has greater paint adhesion with less undercoat corrosion.
- It has high fatigue life with great toughness.
- It has greater resistance to abrasion or wear.
- It is readily and easily welded by any process.
- It polishes to a high lustre at minimum cost.

And with all these physical advantages over mild carbon steel – it can be cold formed as readily into the most difficult shaped stamping.

When you next start to redesign, get the facts on N-A-X HIGH-TENSILE. It's produced by Great Lakes Steel – long recognized specialists in flat-rolled steel products.







N-A-X Alloy Division

GREAT LAKES STEEL CORPORATION

Detroit 29, Mich. • A Unit of

NATIONAL STEEL CORPORATION

Caterpillar protects the

Snaking giant logs through a forest near Washington, Calif., a Caterpillar D-8 Crawler Tractor demonstrates its world-famous durability. To insure dependable performance, Caterpillar uses Bundyweld Tubing for vital oil and hydraulic lifelines.

BUNDYWELD IS DOUBLE-WALLED FROM A SINGLE STRIP

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .

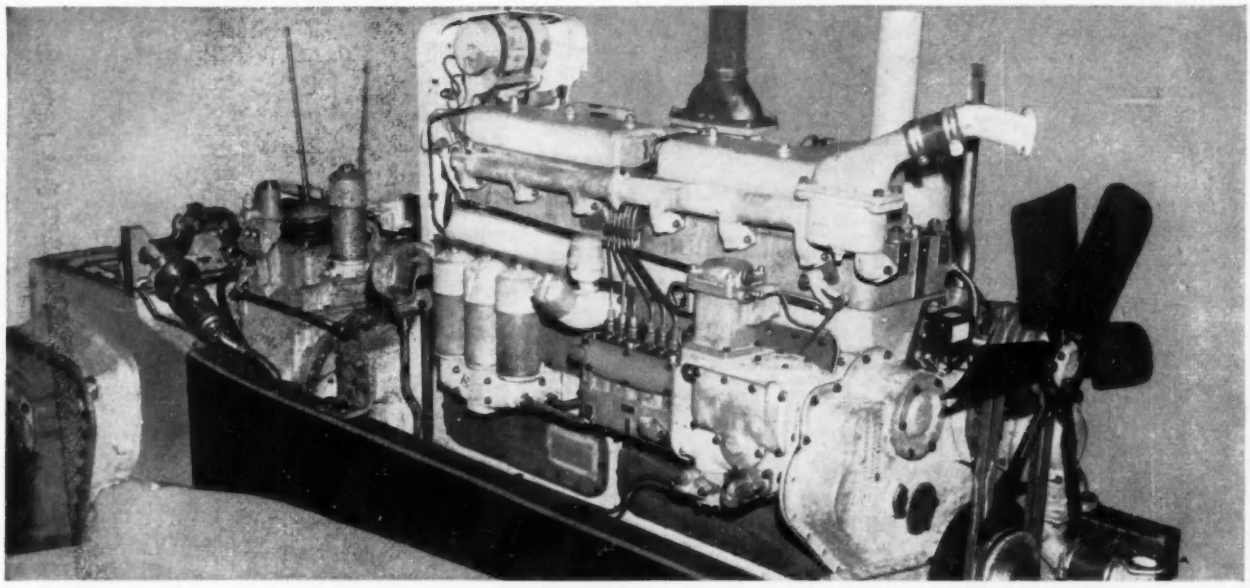
Bundyweld, double-walled and brazed through 360° of wall contact.

←

NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.

reputation of its tractors with lifelines of Bundyweld Tubing

. . . the extra-sturdy steel tubing that's double-walled from a single metal strip and copper-bonded through 360° of wall contact



Caterpillar diesel engine, showing Bundyweld oil and hydraulic lines in copper color.

IF PAUL BUNYAN'S famous blue ox, Babe, were still around today, she'd find mighty tough competition from logging machinery like the Caterpillar D-8 Tractor shown here.

For powerful Caterpillar Tractors are built to take punishment year after year, and still give top performance. Every component part of these diesel-engined beauties must combine strength and durability. That's why you'll find Cat machinery equipped with oil and hydraulic lifelines of Bundyweld Steel Tubing.

Bundyweld Tubing is thinner-walled, yet stronger; leakproof by test. It can withstand heavy vibration fatigue, take punishing wear that would ruin ordinary tubing. And only Bundyweld Steel Tubing is double-walled from a single metal strip, copper-bonded through 360° of double-walled contact.

Your product will benefit from Bundyweld's high quality. And you can benefit from these special Bundy® services: world's finest tubing-fabrication facilities; expert technical assistance; and prompt, on-schedule deliveries.

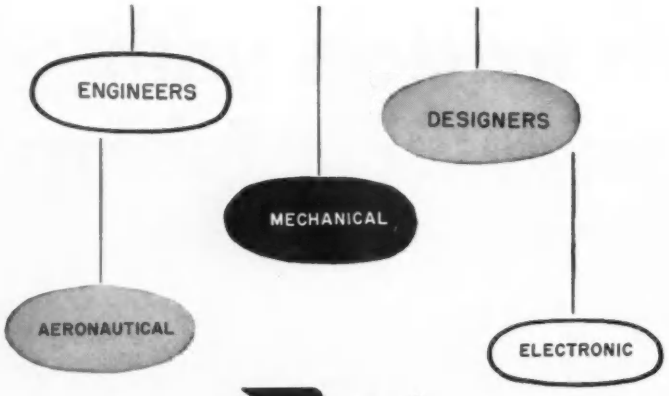
For more information, wire or write today!

BUNDY TUBING COMPANY • DETROIT 14, MICHIGAN

BUNDYWELD® TUBING

Bundy Tubing Distributors and Representatives: ***Cambridge 42, Mass.:*** Austin-Hastings Co., Inc., 226 Binney St. • ***Chattanooga 2, Tenn.:*** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • ***Chicago 32, Ill.:*** Lapham-Hickey Co., 3333 W. 47th Place • ***Elizabeth, New Jersey:*** A. B. Murray Co., Inc., Post Office Box 476 • ***Los Angeles 58, Calif.:*** Tubesales, 5400 Alcoa Ave. • ***Philadelphia 3, Penn.:*** Rutan & Co., 1717 Sansom St. • ***San Francisco 10, Calif.:*** Pacific Metals Co., Ltd., 3100 19th St. • ***Seattle 4, Wash.:*** Eagle Metals Co., 4755 First Ave., South ***Toronto 5, Ontario, Canada:*** Alloy Metal Sales, Ltd., 181 Fleet St., E. • **Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.**

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING • AFFILIATED PLANTS IN AUSTRALIA, ENGLAND, FRANCE, GERMANY, AND ITALY



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Immediate openings available in research, design, test and development:

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- Electro-Mechanical Design
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AIRCRAFT LANDING GEAR →
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AUTOMOTIVE COMPONENTS →
- Conventional Brakes
- Hydraulic Systems
- Mechanical Design and Test
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- Power Steering

If you are interested in any of these engineering projects, send a summary of education and experience to:

Technical Employment,
Department D-2,
BENDIX PRODUCTS DIVISION OF
BENDIX AVIATION CORPORATION
401 Bendix Drive
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OPPORTUNITIES

BEECHCRAFT is aggressively entering new fields and needs men of imagination to do creative work of top-level importance. BEECHCRAFT is now seeking

SCIENTISTS
PHYSICISTS
ENGINEERS

If you would like to be associated with a leading organization that is large enough to have diversification of product, but small enough to insure recognition of personal ability – for work now going on, and work now being planned for Beechcraft's Boulder, Colorado, special engineering facility, as well as Beechcraft's main plants in Kansas, write today to

The Employment Division

Beechcraft

WICHITA 1, KANSAS

Supervisory research opening in Lion Oil, A Division of Monsanto Chemical Company for qualified person with at least 5 years experience in the formulation of petroleum products and non-automotive petroleum specialties. Refining experience desirable but not essential. Location El Dorado, Arkansas. Integrated refinery operations of moderate size. Real opportunity for advancement.

Address replies to:

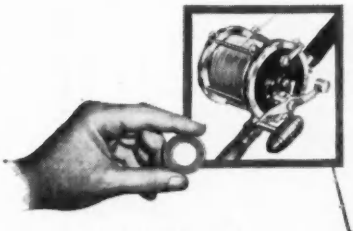
Emmett R. Coley
Technical Recruitment Coordinator
Lion Oil Company, A Division of
Monsanto Chemical Company
El Dorado, Arkansas

MECHANICAL ENGINEERS

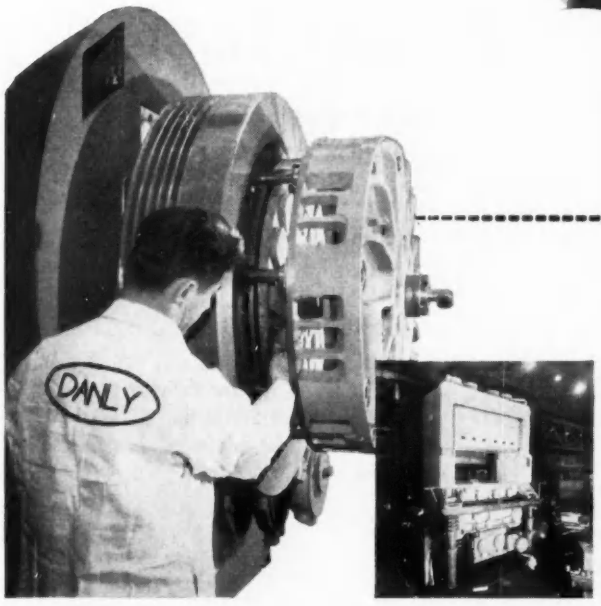
ENGINEERING GRADUATES FOR PRODUCT DESIGN AND APPLICATION. PRODUCTS ARE VIBRATION AND SHOCK ISOLATION SYSTEMS ON AIRCRAFT, ELECTRONIC, AUTOMOTIVE, MARINE, GENERAL INDUSTRIAL EQUIPMENT. THIS IS A RAPIDLY EXPANDING INDUSTRY. EXCELLENT LONG RANGE POSSIBILITIES FOR ENGINEERS WHO ARE INTERESTED PRIMARILY IN DESIGN WORK. DUTIES ALSO INVOLVE EXTENSIVE LIAISON BETWEEN AND AMONG FIELD ENGINEERING, MANUFACTURING, AND RESEARCH.

BOX 369, ERIE, PENNSYLVANIA

Boating a world's record Marlin...



1525-lb. Marlin, the women's world's record, caught by Miss Kimberly Wiss on a Penn Senator Reel with friction drag using J-M Style #600 lining.



or stamping out auto parts...

Two-story high Danly unit for stamping automobile parts using J-M Clutch Disc Inserts.

Equipment can be controlled more efficiently with J-M Asbestos Friction Materials

Johns-Manville Asbestos Friction Materials meet a wide range of applications. Whether you need a tiny brake material for a fishing reel . . . or a rugged clutch facing for a powerful machine press, Johns-Manville can help you.

Precision manufactured, dependable Johns-Manville Friction Materials are available in low, medium and high friction coefficients. These linings and facings are specially engineered to withstand severe shock, maintain friction stability under critical temperatures, provide smooth action at a low rate of wear. If your requirements demand a friction material that must be custom-made for a special use . . . the Johns-Manville Research facilities are available to help develop that just-right formulation.

Whatever your friction material problem, the J-M Friction Materials Specialist is at your service. Or, write for reference booklet that contains a complete description of J-M Friction Materials and a handy selector chart. Address Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville INDUSTRIAL FRICTION MATERIALS

FABRICATION ENGINEER

This is your chance to enjoy the exceptional professional advantages and personal benefits of a key position at General Electric's famed Jet & Rocket Engine Center.

You need a BS degree in Mechanical Engineering or Engineering Physics, plus 2 years of aircraft production design, 2 years of manufacturing engineering and 2 years of production engineering in precision work.

You will—develop manufacturing processes for advanced aircraft engines to reduce weight, cost and materials—evaluate designs—develop appropriate tooling—demonstrate the feasibility of the processes developed—and advance professionally faster and further at this modern, highly-equipped division of General Electric.

Recruiting representatives from AGT will be in most major cities next month. Local interviews for qualified applicants can be arranged.

Replies held in strict confidence:
Mr. Mark Peters, Dept. M8-11
Technical Personnel, Bldg. 100
Aircraft Gas Turbine Division

GENERAL ELECTRIC

Cincinnati 15, Ohio

SALES ENGINEERS STEERING SYSTEMS

Qualifications:

- Knowledge of Steering Systems as applied to Trucks, Buses, Materials Handling Equipment or Tractors
- Engineering degree or equivalent
- Possibly relocate in Chicago or other territories
- Previous Sales or Engineering experience in one or more of the classifications listed
- Knowledge of Hydraulics helpful but not manditory

These positions afford an opportunity to grow professionally with a well-recognized, progressive engineering organization.

Phone R. Barlow, LIberty 9-1122, or address replies to:

Vickers Incorporated
Administrative and Engineering Center
Box 302 **Detroit 32, Michigan**

Want One For Your Lapel?

An SAE Emblem

- **Distinguishes you as an SAE member**
- **Is an attractive gold-filled clutch-back pin**
- **Costs only $1.50**
  plus
  15¢ Federal tax for delivery in the United States and 5¢ sales tax for delivery in New York City

ACTUAL SIZE

GOLD on BLUE ..... **Member Grade**
GOLD on RED ..... **Associate Grade**
GOLD on WHITE ..... **Junior Grade**

Society of Automotive Engineers
485 Lexington Ave., New York 17, N. Y.

Please send me an SAE emblem. Enclosed is my check for $..... ($1.50 plus applicable taxes). Grade of membership (please check)

☐ Member ☐ Associate ☐ Junior

Name .....
(PLEASE PRINT)

Address .....

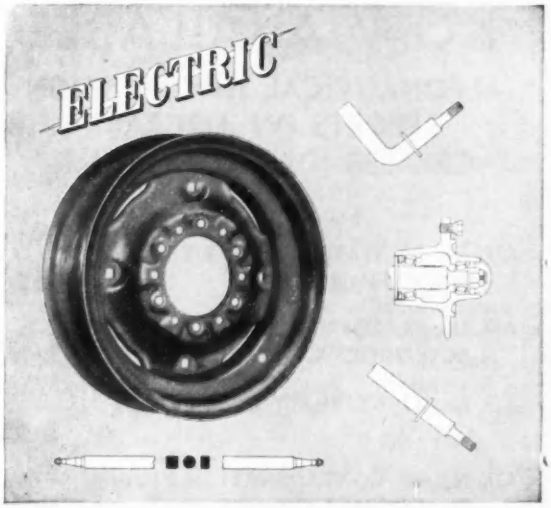
Select California engineering group explores thermodynamic cycles in advanced engines

positions now open for Cycle Analysis...
Thermodynamics...and Nuclear Engineers

Propulsion experts at North American Aviation's Los Angeles Division are carrying out thermodynamic analyses of highly advanced engines. The studies include investigation of turbojets, ramjets, rockets and nuclear propulsion devices... compressors, combustors, turbines, afterburners, exhaust nozzles and thrust augmentation devices.

The Engineering Personnel Department at North American's Los Angeles Division is seeking several qualified engineers who are interested in this work. They are looking for men who have had a minimum of three years thermodynamics cycle analysis experience in jet engines or propulsion analysis. Advanced degrees are preferred though not required.

Interested engineers are invited to contact Mr. W. H. Nance, North American Aviation, Inc., Los Angeles Division Engineering Dept. 56SAE, International Airport, Los Angeles 45, California.



A Wheel for Every Job!

Our engineers will recommend the most efficient and economical wheel and axle assembly for your unit. We invite your inquiries.

WRITE US FOR CATALOG
ELECTRIC WHEEL CO.
2807 SPRUCE, QUINCY, ILLINOIS

4 NEW and 6 REVISED
Aeronautical Standards & Recommended Practices
were issued
March 15, 1956
19 NEW and 16 REVISED
Aeronautical Material Specifications
were issued
July 1, 1956
For further information please write
SOCIETY OF AUTOMOTIVE ENGINEERS, INC.
485 LEXINGTON AVE., NEW YORK 17, N. Y.

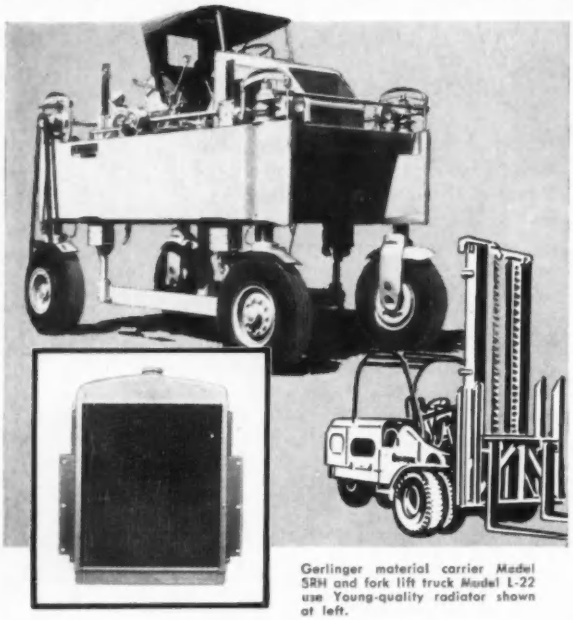
WITTEK HOSE CLAMPS
For Every Type of Hose Connection

Whatever the hose connecting problem, it's a safe bet that WITTEK (leader for over a quarter century) has the *exact* type and size clamp to do the job right! Let WITTEK solve *your* clamping problems. Write today.

WITTEK MANUFACTURING CO.
4342 West 24th Place • Chicago 23, Illinois

Young Radiators

cool the engines that power the "muscles" of Gerlinger weight lifters and carriers



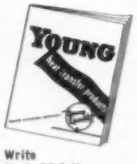
Gerlinger material carrier Model SRH and fork lift truck Model L-22 use Young-quality radiator shown at left.

Young engine-cooling radiators tailored for every automotive application

Young radiators are used wherever the going is tough. So, when a Gerlinger material carrier loads up with 30,000 lbs., or a fork lift truck hoists and maneuvers a half dozen or more tons, powerful engines have to be kept cool! Here is where Young radiators prove their quality. On Gerlinger equipment, as well as on many others, Young radiators provide the specific answers to heat transfer problems. Patented features insure maximum heat transfer and give Young cores a dependable ruggedness. In the automotive field Young produces radiators to cool lube oil or torque converter fluid and engine jacket water.

Put Young Talent to work for you . . .

Solving heat transfer problems is what we do best because it is our very reason for being. You, too, can harness the power of Young engineering talent. Write, wire or call without obligation.



Write Dept. 116-K for FREE Catalog

Young RADIATOR COMPANY
RACINE, WISCONSIN
Creative HEAT TRANSFER ENGINEERS FOR INDUSTRY
Heat Transfer Products for Automotive, Aviation and Industrial Applications. Heating, Cooling, Air Conditioning Products for Home and Industry.
Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Mattoon, Illinois

Over 85% of the torque wrenches used in industry are

STURTEVANT TORQUE WRENCHES

Read by Sight, Sound or Feel

- Permanently Accurate
- Practically Indestructible
- Faster—Easier to use
- Automatic Release
- All Capacities

in inch grams
...inch ounces
...inch pounds
...foot pounds

Every manufacturer, design and production man should have this valuable data. Sent upon request.

P.A. STURTEVANT CO.
ADDISON QUALITY ILLINOIS

NOW AVAILABLE

AERONAUTICAL INFORMATION REPORTS ON AIRCRAFT GREASES (DATED MARCH 1, 1955)

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AIR No. 40, CORROSION PREVENTIVE CHARACTERISTICS OF AIRCRAFT GREASES $0.75

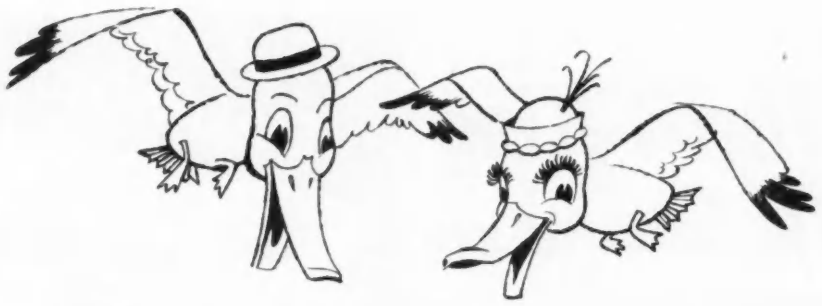
AIR No. 41, STABILITY OF AIRCRAFT GREASES $0.50

AIR No. 42, CONTAMINATION STUDIES OF AIRCRAFT GREASES $0.50

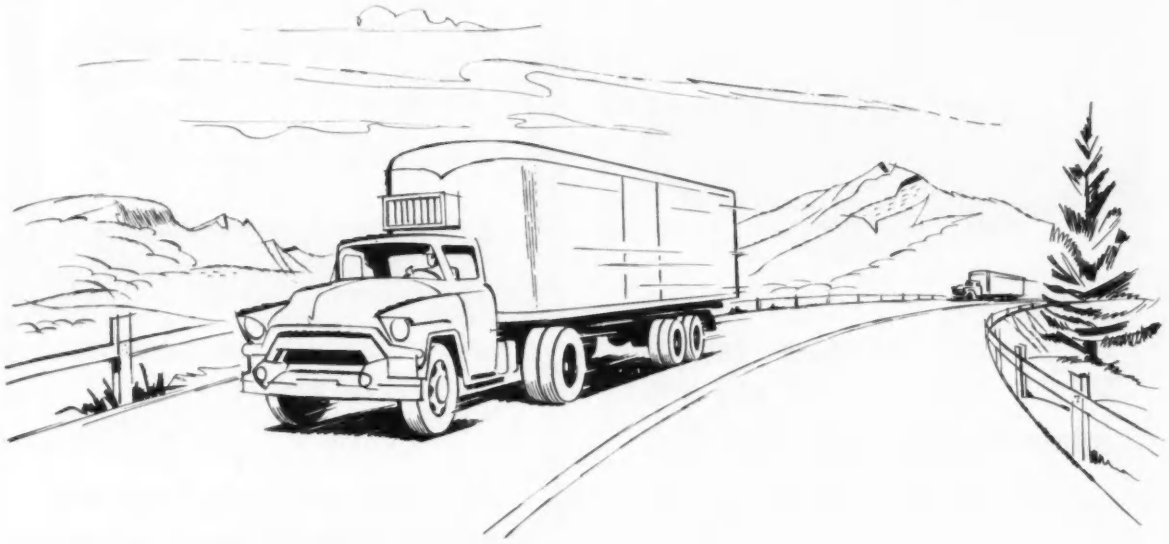
AIR No. 43, LOW TEMPERATURE TORQUE TEST FOR AIRCRAFT GREASES $1.00

AIR No. 44, LOAD SUPPORT CHARACTERISTICS OF AIRCRAFT GREASES $1.00

SOCIETY OF AUTOMOTIVE ENGINEERS, Inc.
485 LEXINGTON AVE., NEW YORK 17, N. Y.



They are also birds of a feather ...all have SKF® bearings



By flocking to a single source where all basic types of bearings are available, many in the automotive industry are fast becoming "birds of a feather."

They share a common knowledge that **SKF**'s complete line provides a bearing with *plus values* for every application.

Why not profit by their experience, and wing your way towards **SKF**, today. 7732

SKF

EVERY TYPE—EVERY USE

- *Ball Bearings*
- *Cylindrical Roller Bearings*
- *Spherical Roller Bearings*
- *Tapered Roller Bearings* ("Tyson")

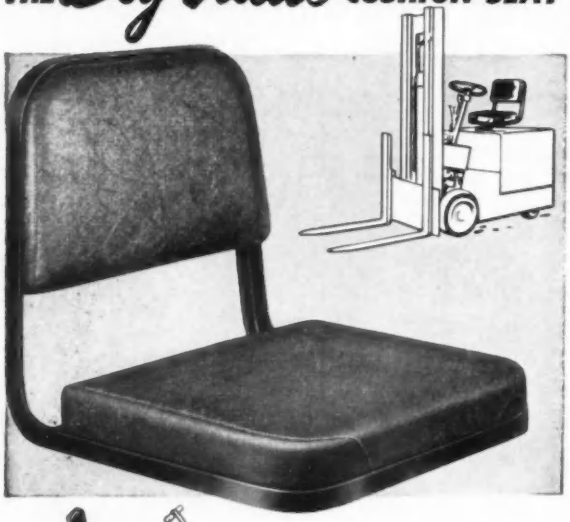
* Reg. U.S. Pat. Off. Tyson Bearing Corporation

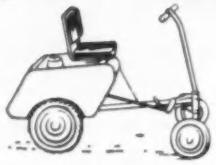
SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

CONTOUR
Milsco
MILWAUKEE
SEATING

Thrift-King

THE Big Value CUSHION SEAT





For POWER MOWERS, LIFT TRUCKS AND OTHER MEDIUM MOBILE EQUIPMENT

"Thrift-King" is a 2-way value seat for manufacturers of lift-trucks, mowers, and many types of medium mobile equipment: it definitely adds "sell;" it definitely improves workability. Full cushion foam rubber seat and full cushion foam rubber back rest assure sustained comfort and operational freedom. Wide choice of covering materials that will withstand outdoor use. Frame is of solid one-piece welded construction for rigorous service; easily attached. Available as illustrated, or with special features engineered to your equipment.

Write for complete information on America's finest line of cushion seating — Milsco.

MADE TO FIT YOUR NEEDS

MILSCO MANUFACTURING COMPANY
FACTORY AND MAIN OFFICE
2758 NORTH 33rd STREET MILWAUKEE 45, WISCONSIN

SALES OFFICES: Tom Riley, 67 Long Lane, Upper Darby, Pa
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Specialists in Cushion Seating

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GASKETS FOR INDUSTRY

For nearly half a century we have specialized exclusively in the non-metallic gasket field.

We have developed many new materials and treatments, including treated fibres, synthetic rubber, asbestos and beater mix materials.

We have solved many difficult gasket problems. Put us to the test. Write for our technical reference booklet called "GASKET HANDBOOK". We will be glad to send you samples for testing in your own plant.

Our sales engineer in your territory is always available for consultation.

VELLUMOID COMPANY
56 ROCKDALE ST. · WORCESTER, MASS.

ENGINEER, ME EE or AE

Controls Design Nuclear Aircraft Engines

First came the propeller, followed by the jet engine—and now, aircraft nuclear propulsion with its tremendous power potential. General Electric's ANP Department has a career opening for the qualified engineer who desires to achieve the professional stature his talents deserve.

The present position requires 1 to 3 years' experience in aircraft control or accessory systems design and application, and involves the design of turbine type engine controls. Both creative and analytical ability are desirable.

Openings in Cincinnati, Ohio and Idaho Falls, Idaho

Address replies in confidence stating salary requirements, to location you prefer

J. R. Rosselot
P. O. Box 132
Cincinnati, Ohio

L. A. Munther
P. O. Box 535
Idaho Falls, Idaho

GENERAL ELECTRIC

XVII

This is the seventeenth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Uses of Aluminum in Alloy Steels

Aluminum as an element has been known to chemists and metallurgists for many years. It is never found in nature in its metallic state, being derived chiefly from bauxite, an aluminum hydroxide. Bauxite is present in various parts of the world, including several tropical and semi-tropical regions.

When used in the making of alloy steels, aluminum has several important functions. Because of its great affinity for oxygen, it is a reliable deoxidizer. It produces fine austenitic grain size. And when it is present in amounts of approximately 1 pct, it promotes nitriding. The nitriding process could be described as surface- or case-hardening by means of a nitrogenous medium, or by heating in an atmosphere of ammonia gas and dissociated ammonia mixed in proper proportions.

Other effective agents in producing nitrided cases are chromium, vanadium, tungsten, and molybdenum. As a rule, however, the hardest cases are obtained with aluminum-bearing steels, the nitriding grades being a good example. These are usually steels of medium carbon content with additions of chromium, molybdenum, and sometimes nickel.

Generally speaking, the lower the effective nitriding temperature, the harder the case will be. Aluminum-bearing steels usually show a case-hardness range of 950 to 1150 DPHN (diamond pyramid hardness number). Steels in which no aluminum is present have cases of substantially lower hardness.

If you would care to know more about aluminum as an addition or alloying agent in steels, Bethlehem metallurgists will gladly give you full information. Just write or call us; our technicians are always at your service. They will do everything possible to help make your problems easier. And whenever you need new supplies of alloy steels, remember that Bethlehem manufactures the full range of AISI standard alloy grades, as well as special-analysis steels and all carbon grades.

If you would like reprints of this series of advertisements from No. I through XVI inclusive, please write to us, addressing your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa. The first 16 topics are now available in a convenient 32-page booklet, "Quick Facts About Alloy Steels," and we shall be glad to send you a free copy.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

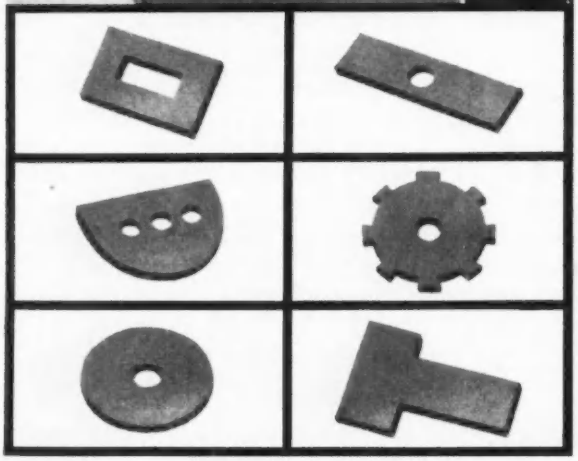
BETHLEHEM STEEL

BETHLEHEM STEEL

Use sponge rubber?

U.S. Kem-Blo® SPONGE

- is a superior, light, flexible, elastic, sponge rubber.
- takes hundreds of thousands of compressions without matting down.
- can be engineered to any width, shape, thickness or compression.
- perfect for insulating, gasketing, cushioning, weather-stripping, dust-proofing, shock-absorbing, sound- and vibration-damping.



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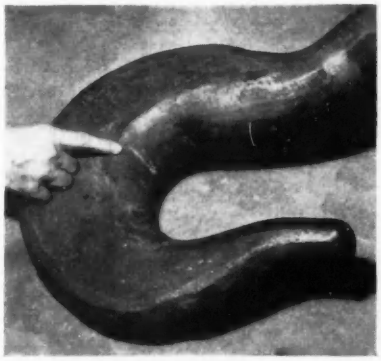
THE ELECTRIC DETECTIVE is an apt description of the Magnatest FM-100 Conductivity Meter. Magnatest uses the electrical conductivities of materials as a measure of uniformity, hardness, purity and other characteristics. A small hand held coil induces eddy currents in the test material, which in turn affect the impedence of the coil in proportion to the conductivity of the material.



IT'S JUST A LITTLE CRACK, but it's a serious matter when it shows up on an industrial crane hook. In fact, to the naked eye it may appear to be a scratch, at most. Yet it can open further and further under load. The end result: failure in service and subsequent costly damage. Photo above shows a Magnaflux indication of such a crack in a crane hook.

THE HALLMARK OF THE BEST SYSTEMS FOR NONDESTRUCTIVE TESTING

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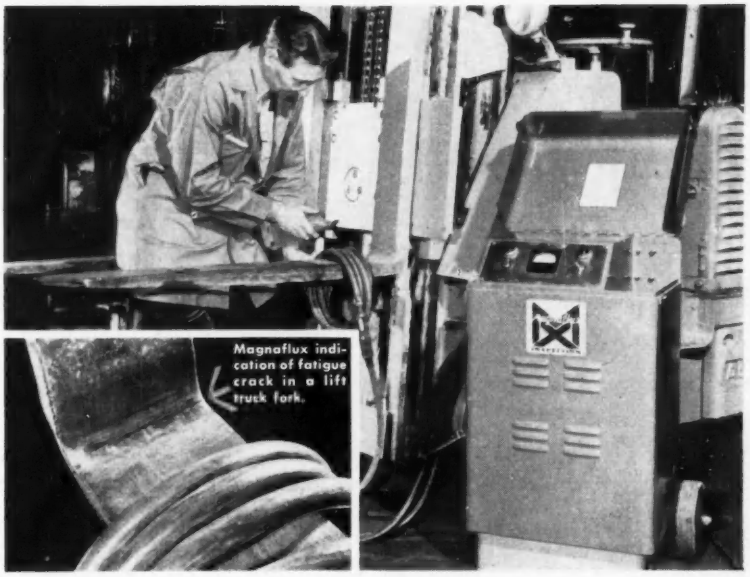
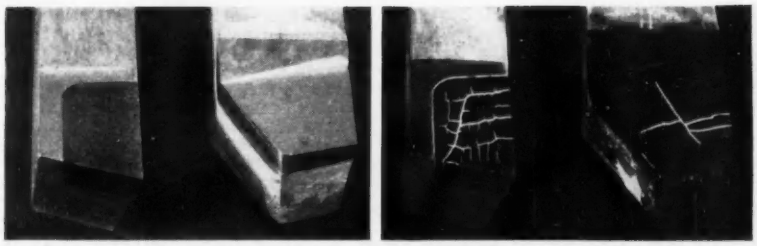


How Periodic Inspection Ups Production by Preventing Equipment Failures

When industrial equipment fails in use, it usually results in lost time, production, or even life! In each case there is a corresponding loss of money. The amount, of course, depends upon the circumstances. Periodic inspection with an M testing system can foretell the exact nature and extent of structural weaknesses in your machinery, tanks, or equipment.

Invisible hairline cracks are warning signs of future fatigue failure. The M tests detect such signs in any material. You can take the proper corrective steps in time to prevent costly production interruptions. Nondestructive testing can help you eliminate profit-draining equipment failures. —Investigate Magnaflux inspection methods today!



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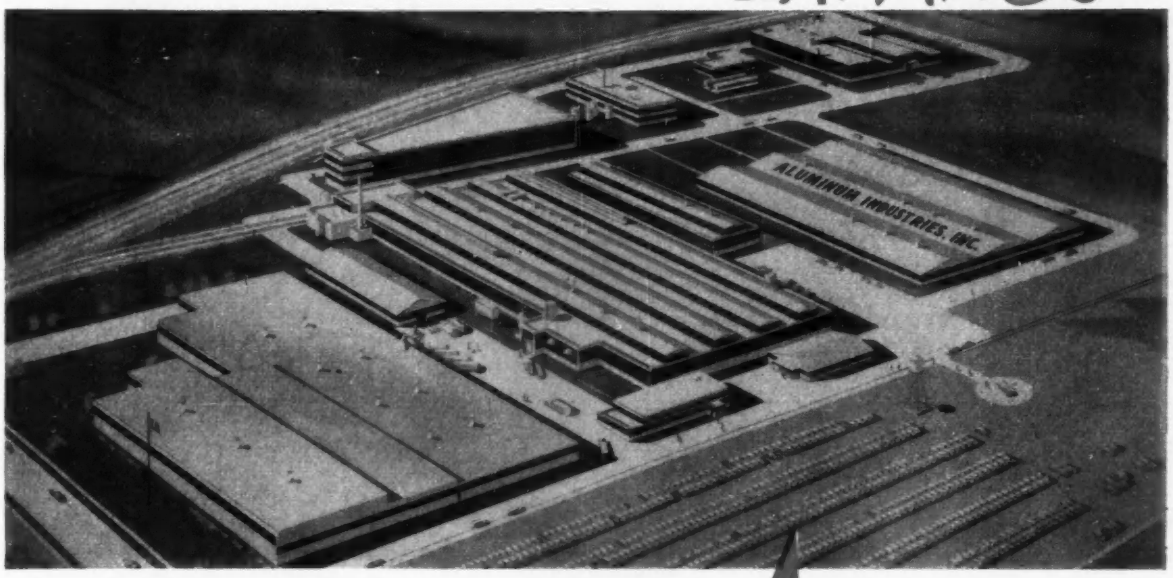
ALUMINUM INDUSTRIES, Inc. EXPANDS...



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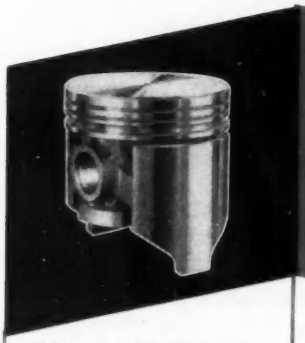
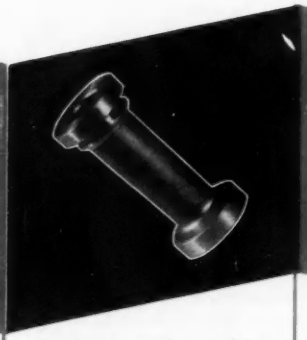
Our well advanced expansion program is a logical development of our responsibilities as a major supplier to the forward-looking automotive industry. As new concepts of performance, safety and design are put into practical production, Aluminum Industries' experienced engineering *"know how"* and *ever-expanding production facilities* are ready and eager to serve your requirements.



When, many years ago, automobile builders first sought *lighter weight, better performing pistons,* they found the answer in aluminum pistons by Aluminum Industries, Inc.

Later, searching for *longer-life engine valves,* they again turned to Aluminum Industries. We created the Bi-Metal Valve . . . then added nitrogen! Result: 25% greater strength, 40% increased hardness at elevated temperatures.



For better brake performance, Aluminum Industries developed the *master cylinder brake piston* that quickly became the standard for virtually all automotive vehicles.

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what this trade-mark means to you

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Over the years and economic cycles, customers of American Felt Company have learned that grades bearing this trade-mark can be trusted to be of the finest quality, fairly priced and backed by utterly dependable service.

During the 58 years this trade-mark and the Company have been privileged to serve its many valued customers there have been occasions when pressure has been brought to bear on American Felt, and its worthy competitors, to lower standards in order to meet a temporary price situation. Once again that situation threatens. But American and others will, as in the past stand firm.

Every sensible business man knows you get what you pay for. Indiscriminate price cutting can result in only one thing . . . everybody loses . . . even the customer who thought he was getting a bargain.

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American Felt has never decried fair competition. Rather it welcomes it because it is good business and good for business. In fact, competition is the very foundation on which American business has been successfully built.

So, on behalf of the felt industry, and for the good of your relationships with *your* customers, we urge you to make certain that the felt *you* buy bears a trade-mark that has, through the years, stood for only the highest quality product.

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for disc implements
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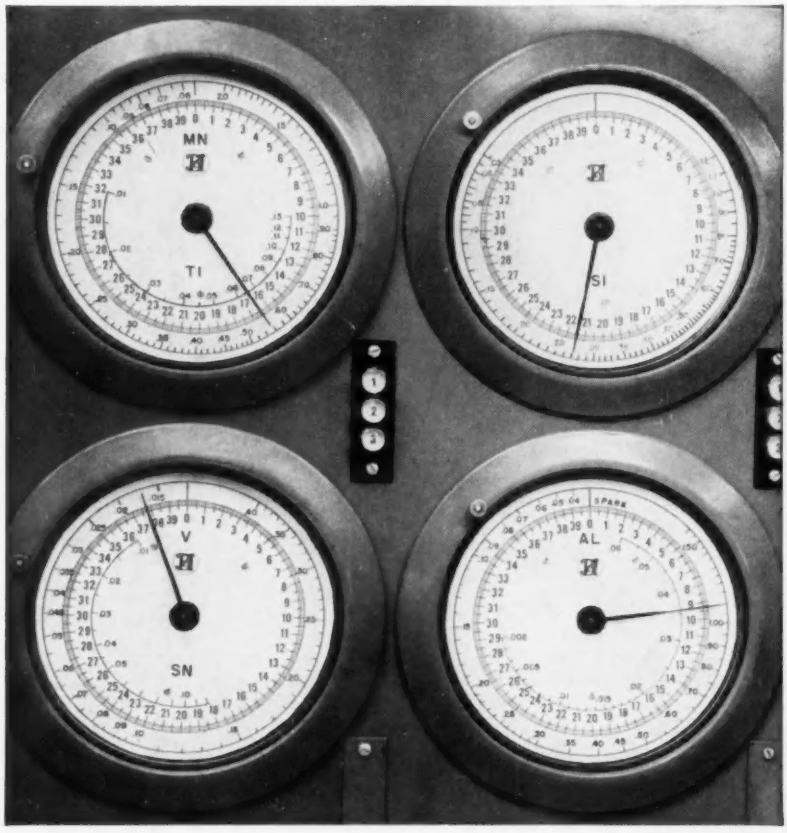

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YOU see above four of the twelve spectrometer dials used to analyze steels being melted at the Timken Company. In just 40 seconds this direct-reading spectrometer tells the exact chemical composition of a heat of Timken fine alloy steel. Results are flashed back to the furnace so the melter can keep close control of the analysis. This carefully controlled chemistry produces uniform composition from heat to heat. You can be sure that forgings made from Timken® forging steels will give you uniformly high ductility and resistance to impact.

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